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I

STATESMANSHIP AND SPECIALIZED LEARNING

By A. N. Whitehead

Harvard University

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This series of addresses is devoted to the consideration of the ways in which learning derived from the systematic study of Arts and Sciences can profitably influence the reorganization of civilization in the future beyond this war. In so far as the world of learning today possesses a capital city, Boston with its various neighboring institutions approximates to the position that Paris occupied in the Middle Ages. Thus the importance of discussions initiated by these lectures cannot be doubted.

This first lecture is concerned with a preliminary topic—namely, the wide influence of social coordination on every feature of human life, and by contrast the specialized limitations of every type of learning. There is thus a gap between Statesmanship and Learning.

Our first impulse is to deny this gap. We point to the various departments of social sciences which exist in every university in the neighborhood of Boston. There are even departments for the training of government officials. This is true and these departments are doing a good job. But their purpose is very restricted. They *either* deal with very wide generalities concerning human existence, *or* they are confined to the specialties of some particular type of social coordination, for example, life in some South Sea Islands, or life amid the governmental activities at Washington, D. C. My point is that a survey of the World between the South Sea Islands and the District of Columbia in the United States, discloses a most perplexing number of types of social organization. The two phrases—namely, 'social coordination' and 'social organization'—are apt to be misleading, by reason of their omission of any reference to the *activity* which is an essential character of life. The term 'social cooperation' is nearer to the truth in expressing the problem of human life. We are apt to think of change in the past as the substitution of one static system in the place of another static system. A great deal of learned history supports this false perspective. When I look back upon my own young life during the remote period of the eighteen-seventies, it was largely dominated by the study of history. But curiously enough in my imagination History ended with the Battle of Waterloo in the year 1815. Since then, the generations of my grandfather, and my father, and my own young school companions, were just living. This process of living was not History. It was mere daily activity. History in my imagination was concerned with the conflict of static organizations such as England, France, Spain.

The dispatches of statesmen unconsciously falsify contemporary life. They have to take the general set-up of emotional activity for granted and conceive of the adjustment of detailed consequences. But in altering the details the whole emotional structure is affected. For example, consider this country in the decade from 1860 to 1870. There was a desperate struggle issuing in large-scale changes. But the importance of these changes consisted in the deep transformation of emotional relations. The conclusion from these considerations is the importance of the Arts for the understanding of human life. This is a meeting of The American Academy of Arts and Sciences. During the last hundred years there has been a resolute attempt to turn Arts into Sciences. The founders of this Academy were right, there is a real distinction between the two. The Arts are concerned with the various types of emotional satisfaction, including the sense of correctness, and the Sciences with the various patterns which can be discerned and tested amid the activities of nature. In the Arts the pattern is a construction explanatory of the emotional satisfaction; in the Sciences the interplay of patterns is the essential consideration. The comprehension of existence requires the combination of Arts and Sciences. In concrete human action, there is always a Science lurking behind an Art and there is always an Art stimulating a Science. This is the reason why one Academy should include both Arts and Sciences.

In the analysis of the necessities of human existence the Sciences take precedence. On the other hand, when we are considering the purposes which should guide our action, the Arts are in the foreground, and Sciences in the background determine methods of procedure towards the goal defined by the Arts. Of course if our actions are predetermined in every detail, this whole discussion is a silly make-believe which we cannot avoid because it is predetermined by the frivolity of the Universe. I rather suspect that this is the predominant doctrine in this audience. You must forgive me, because it is predetermined that I proceed on the contrary hypothesis.

The Arts take many forms—painting, sculpture, music, the analysis of the beauties of nature, cookery, and dancing, and architecture, and the decoration of the human body. The two Arts most relevant to these discussions of our Academy are aspects of recollection and anticipation, enlarged and stimulated by verbal expression—namely, History and Literature. The essence of History is description of the physical activities of the mankind in the past, with their function of eliciting various forms of emotional experience. The emotional experiences of mankind are essential to History. For example, it is not the mere fact that two heads were detached from two human bodies that is History—the History is the emotional convulsion of the European world produced by the execution of Charles I of England, and of Louis XVI of France. Of course it is the business of historians to make it certain that the heads in question were in fact detached from their bodies. Thus the function of History is the display of emotion derived from verified facts. Social Literature is very analogous to History, but it has a wider scope. It is concerned with facts which might have happened, or perhaps did happen, and with the emotions which might have been derived from those facts. But in another sense, such Literature has a narrower scope than History. Such Literature must in some sense be believable, whereas experiences of human beings in fact develop beyond all powers of conjecture. Thus Social Literature is conventional, while History exceeds all limitations of common sense.

In this short discussion of the function of the Arts in the interpretation of human behavior I have been using the term 'emotion' in a very extended sense, to include all activities of feeling and discrimination which lead to action, enjoyment, or purpose.

Science is concerned with the relatively stable patterns of activity which in fact dominate existence so far as we can observe it. Such stable patterns are essential factors for the determination of human behavior. But our scientific knowledge is only partial, and is restricted to average results. Science knows nothing of detailed eccentricities or of the gradual loss of stability as some patterns vanish and give place to others. Some type of eccentricity in the past is then becoming normal. In this characterization of science I am merely agreeing with a statement by the late President Eliot of Harvard in one of his letters, written many years ago. I refer to him, because among other great qualities he was the incarnation of sound sense.

After this preface we can now turn to the function of this Academy in the present crisis of human existence.

Human beings are complex, various, delicate, excitable, and purposeful. They require a stable social organization in order to preserve them, and a large variety of opportunity to elicit their individual capacities. But these requisites are ideals. What in fact we can hope for is a sufficiently stabilized society to preserve life, with some very limited opportunities for the expression of individuality. This second requisite is the meaning of freedom.

These practical limitations of freedom make it necessary that those types of opportunity which a social system embodies should be relevant to the dominant desires of the populations concerned. It is not true that every society exhibits the same predominant desires among its members. Thus the first step in political wisdom is to recognize this astounding distinction between social groups.

Almost all effective thought belongs to one or another of two extremes: namely, either complete abstraction from any special circumstances or complete concentration upon one special group of occurrences. Induction is an effort to broaden the speciality of concentration. Experience has proved that induction is a very slippery customer. The greatest success in its use has been to suggest some broad abstraction such as the notion of Genera and Species, or the doctrine of Gravitation combined with Newton's Laws of Motion. Neither of these abstractions is quite true; but they have created modern science. For political thought induction from one society to another is most dangerous. It is useful in widening the range of imagination; but its naïve application is fatal.

A minor incident mentioned in the newspapers a few weeks ago illustrates this point. The America Government, pursuing the doctrine of Freedom, of which it is so justly proud, is arranging for the emancipation of the Phillipine Islands from American control. This is a splendid example of a noble principle. But it turns out that one of the smaller islands is inhabited by people of different origin, different habits, and different beliefs, from the general population. These people of that Island have been completely satisfied with the

American supremacy: their ways of life are protected. But they view with horror subservience to an independent Philippine Government. It means destruction to them. This is a minute illustration of the whole problem of political reorganization.

Of course there is nothing insoluble in any one of these problems. But a simple-minded approach to practical politics is disastrous. In each particular case there are always special factors which must not be neglected.

And yet, when all this has been said, the large generalizations of science founded upon wide abstractions, only partially relevant to any particular case, provide the essential basis for all sociological re-construction. Within this century, science has provided new techniques, throughout its whole range from medicine to engineering, which are producing the greatest sudden revolution ever experienced in the habits of mankind. The world has shrunken in size, and has expanded in opportunity. Today the adventure of ideas is the discovery of opportunity.

Our discussion now passes to the special problem of political reconstruction after the war. This preliminary address is only concerned with the general outlook.

We shall be faced with a completely disrupted social system, in confusion physically, emotionally, and ideologically. This statement certainly applies to Europe, and to large portions of Asia and Africa. Also it must be remembered that sociological disruption is the most contagious disease known to mankind. Thus the first requisite is that order be imposed. There can be no civilization apart from a well-organized system of inter-related activities, within which the intimacies of family life can be developed.

Human life discloses many types of social order existing in the world, and—what is more perplexing—a great antagonism between adjacent groups in respect to differences of kinds of order, kinds of emotion, and of individual human beings produced by those various types. The love of humanity as such is mitigated by violent dislike of the next-door neighbor.

For this reason, no single world-wide solution of the social problem can be successfully adopted. Each special district must be studied with a view to the immediate solution applicable to it. There can be no one general system of social coordination which does not destroy the special capacities of smaller groups. The essence of the world-wide sociological problem is the study of the modes of grouping mankind subject to some coordination of the various groups. Of course, this conclusion is a commonplace for all successful government. In this country, there are forty-eight States, and the District of Columbia, all supervised by the Central Government. Also in each State there are cities, counties, and townships, each with its freedom of action within limits.

Thus there must be a careful study of the possibilities of grouping, and of coordinatiing groups in different areas—for example in the Mahometan world of the Middle East, including Egypt; and in Central Europe stretching from the Baltic to the Aegean Seas with Russia and the Mahometan world on one side, and Germany and Italy on the other side. There is Western Europe, with its various groupings. Also there is the coordination of these groups.

But we have omitted the fact that owing to modern techniques the world in the future will be immeasurably more compact than in past history. India, and China, and the Oceanic Islands of the Eastern and Southern Oceans, and the two Americas which separate the ancient East from the ancient West, will be in essential, immediate connection with the small European and Mahometan Worlds, which first claimed attention. It is here that this Academy is of importance. Traditional statesmanship must be infused with the dramatic novelty which the immediate future presents. Among the people most responsible for this duty are the members of Academies of Arts and Sciences. They can compare the modes of action in the past with the novel possibilities of the future. It is their business to inform the populations and to guide the statesmen. Above all, it is their business to cooperate with each other, and not to exaggerate the petty views of the Universe which their own specialities present.

A stable order is necessary, but it is not enough. There must be satisfaction for the purposes which are inherent in human life. Undoubtedly the first essential requirement is the satisfaction of the necessities of bodily life—food, clothing, shelter. These economic factors are dominant up to the level of moderate enjoyment. They then almost suddenly become the mere background for those experiences which form the distinction between mankind and the animal world. It is the imaginative originality of mankind which produces ideals, good or bad. We live guided by a variety of impulses—towards loving relationship, towards friendship, towards other types of enjoyment such as games, art, ideals of mutual enterprise, and ideals disclosing some sense of immortality. This intimate development of human experience enters into political theory as respect for each individual life. It demands a social structure supplying freedom and opportunity for the realization of objectives beyond the simple bodily cravings.

Of course any one group of human beings, however large, has a very finite set of appetitions, depending on past history and on the sort of prevalent ideals. In every social system there are exceptions, mostly foolish but some of them beyond price. It is of the essence of good government to provide some adequacy of satisfaction both for the large communal motives, and for all reasonable exceptions on which progress depends. It cannot be repeated too often, that the only security for progress is a sincere respect for each individual human being.

As we approach these problems the first words that occur to us are 'freedom' and 'democracy.' The preceding discussion has been devoted to elucidating the fact that 'freedom' apart from relevant 'opportunity' is a meaningless notion. Robinson Crusoe could do what he liked on his island: but, until the savages turned up, there was nothing for him to do. The history of mankind with its wars is the tale of groups of people seeking opportunity by the oppression of their neighbors. Sometimes these wars sink into minor disturbances and are conventionalized, as in the late middle ages and in the eighteenth century.

The enthusiasm for crusades—Mahometans attacking Christians or Christians attacking Mahometans—illustrates the poverty of life in the Middle Ages. Also slavery, or half-slavery, by eliminating the claims of a large portion of the population, preserved the limited store of opportunity for the fortunate minority. Today the notion of a master-race is being revived, and most of us are agreed that it means the moral degradation of mankind.

Within the last four centuries there have been three dramatic disclosures of new large-scale opportunities. I put aside the Italian Renaissance for it only concerned a fortunate minority. It was the last spurt of the Middle Ages. Thomas Aquinas would have enjoyed it.

The first disclosure was the discovery of a new world—namely the half-empty continent of America, as the immediate result of the new technique of oceanic voyaging. The real discovery was in fact the new art of navigation, and America was the first gift derived from it. The history of civilization opens a new chapter at this period, by reason of this increase of opportunity. The problem of existence was not solved; but hope entered into human life as never before. The three countries most concerned—namely, Spain, the Netherlands, and England—for the period of about 150 years starting with the sixteenth century, exhibit a stage of excited hopefulness, while unfortunate Germany was torn to pieces by disputes inherited from the Medieval World. France was balanced between the two periods, and developed the brilliance of the old European civilization. The intensity of the French Revolution showed that novel opportunity had not penetrated throughout the nation.

The second enlargement of opportunity began about two and a half centuries after the first. It was the industrial revolution which gradually developed from the middle of the eighteenth century, with its two culminations in the invention of the steam engine, and the invention of the railway. Human life was transformed.

I am inclined to believe that its best effect was in opening the whole extent of North America to the European population. This was due to the steamboat and the railway. But nothing great in human history is due to a single cause; and we must also add the influence during the American Revolution of great statesmen guiding a peculiarly intelligent people.

At least, the new techniques transformed life throughout the world, more especially in Europe and America. In western Europe during the second quarter of the nineteenth century there was a period of optimism. The problem of human life seemed to have been solved, and the first International Exhibition in London, during the year 1851, celebrated this glorious triumph with the creation of the famous Crystal Palace.

Alas, something was missing. It may have been the want of intelligence among statesmen and industrial leaders. It may have been that the development of techniques was less fundamental than it seemed. Whatever the reason, the Crystal Palace, very symbolically, has been burnt down; and the nations are now struggling to avoid the ancient evil, which is the selfish mastery of the few over the many.

At the present time, we are in the first phase of the third enlargement of opportunity, perhaps the most important crisis in the history of civilization.

The intellectual development of mankind, with its self-conscious criticism, has a recent growth of some five or six thousand years. Its earlier stages seem to consist of traditional legend with the minimum of coordination. But about two thousand six hundred years ago, a widespread movement of critical judgment on the nature of things had established itself. The European races derive their special systems of thought from the brilliant races in the Eastern Mediterranean and the Near East, more especially from the Greeks. But in the course of ages the centre of activity has moved backwards and forwards through many races from Mesopotamia to the Straits of Gibraltar. It has also spread northward. There were analogous movements in China and India; and the three intellectual growths fed each other intermittently. But European systematic thought has shown the greatest energy both in self-criticism and by its contact with practical activity. Today it is refashioning the ways of thought and action in every civilized race of the World.

The result has been a gradual broadening of opportunity. But this growth has been intermittent, and wavering. Slavery became serfdom, and serfdom became free laborers on the edge of starvation. The status of the workers improved, although the slums of industrial cities disgraced industry. Indeed at the very moment when the Industrial Revolution was in its prime, Malthus managed to prove that the mass of mankind must always live on the verge of starvation. He was only answered by the nearest approach to an appeal to Divine Providence that men like John Stuart Mill dared to make. Every factor involved in human existence is too variable to justify these sweeping statistical deductions based on past experience.

As an historic fact, the gradual introduction of novel techniques has broadened the amplitude of opportunity for the mass of mankind, slowly and waveringly. Within the past five or six hundred years there have been certain crises in this slow advance, due to these novel techniques. These critical techniques are not the most interesting facts for abstract thinkers, but their immediate effect was overwhelming. For example, the evolution of trans-oceanic navigation, as distinct from coastal voyaging, is not very interesting for abstract learning. But it changed the history of mankind. Again, the thoughts of Galileo and Newton were of supreme interest, but the habits of mankind between the dates 1690 and 1750 were very slightly altered. The total effect was that fortunate people had a new theme of intellectual enjoyment. Indeed within this period the introduction of cheap spirits, such as gin, probably did more harm to English life than all the noble thoughts of the Royal Society did good. But the growth of Science did arouse an alertness of intellect. The result was the Industrial Revolution in the hundred years between 1750 and 1850.

Today we are at the beginning of a new crisis of civilization, which gives promise of producing more fundamental change than any preceding advance. The growth of science in every department of thought seems to have reached a stage where the whole spread of knowledge discloses new possibilities for practice. This holds throughout the whole range of activities, from medicine to engineering, from mining to aerial flight, from the use of the microscope to the waves of energy from remote nebulae, from psychoanalysis to geology. The whole of human practical activity is in process of immediate transformation by novelties of organized knowledge. It is no longer a question of a new detail such as gunpowder, or printing, or the power of steam, or the novel machinery, or a new aspect of religious thought. Today, the whole extent of learned thought is transforming every activity of mankind. This is the largest epoch in human history. Historical knowledge is essential, but very dangerous. The old phrases are misleading. For example, in this country it is no longer sufficient to tell young people to 'Go West in a covered wagon.' In my own country (England), the old habits must be completely reformed. Again, we must insist, History is essential for the direction of action but its naïve application is very dangerous.

Still more dangerous are the simple-minded generalizations of specialized scientists beyond their own limits of special knowledge. The truth is that we must work together. Historians must study the new possibilities of action; and scientists must learn the old chequered history of human emotion passing into large-scale social activities.

There is one prophecy upon which I will venture. It is that throughout the vast land-areas of the Old World—Russia and China, for instance—the example of North America will be predominant. Perhaps also America has something to learn from Russia and China.

Also, forgive me when I conclude with a confession of personal political faith. I do not trust any extreme, abstract plan of universal social construction. Such plans are important for the stimulation of the imagination. But in practice every successful advance is a compromise. The general ideal is the wide diffusion of opportunity. The sort of opportunity relevant to each special case depends on special characteristics of the populations involved.

DISCUSSION OF PROFESSOR WHITEHEAD'S PAPER

By Samuel H. Cross

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Presented November 12, 1941 Received April 2, 1942

Professor Whitehead's talk laid down certain general principles which we may recall tonight with profit. You remember his statement that human beings require a stable social organization in order to preserve themselves, and a large variety of opportunity to elicit their individual capacities. "But," he continued, "these requisites are ideals. What in fact we can hope for is a sufficiently stabilized society to preserve life, with some very limited opportunities for the expression of personality." In this last the speaker discerned the meaning of freedom. He likewise pointed out that the practical limitations on freedom "make it necessary that the types of opportunity which a social system embodies should be relevant to the dominant desires of the populations concerned." He reminded us that after the war "no single world-wide solution of the social problem can be successfully adopted," and that "each special district must be studied with a view to the immediate solution applicable to it." Professor Whitehead also made the point that 'freedom' apart from relevant 'opportunity' is a meaningless notion.

Here, it seems to me, is a factor that was not provided for in the settlements after the last war. We established 'freedom,' or 'democracy' (if you like) in a variety of countries, including Germany itself, but without the economic opportunity to make that freedom worthwhile.

In Germany, for instance, the depreciation of democratic institutions (specifically, popular representation in the Reichstag) which set in with Bismarck and continued during the entire reign of William II turned men of energy and intelligence away from political activity into scholarship, finance, and industry, while the jingoistic propaganda of the nationalists tended to increase the authority of the crown, the bureaucracy, and the military caste. Hence when, in the fall of 1918, an attempt was made to transform Germany into a democracy, neither trained democratic statesmen nor a citizenry practised in independent thinking were available to make the system work. At best, an appreciable lapse of time was required before an understanding of the operation of democracy could take root. But this understanding could not be promoted unless the elements of the population likely to achieve it were encouraged and strengthened by the "opportunity" which Professor Whitehead mentioned. For as long as democracy limped because of economic disabilities wished upon it by the very foreign powers which had insisted upon its establishment, it had no vitality or popular appeal, and new weapons were thus placed in the hands of its opponents day by day until the catastrophe of 1933. In general terms, then, given a democratic victory in the future, it will not make much difference what sort of social and political system we establish anywhere unless they possess economic vitality and soundness.

Professor Whitehead referred to ideals. I mistrust ideals in the minds of people who regard the means of approaching them as equally absolute with the ideals themselves, and therefore resent any change in procedure. It is, for example, an American ideal not to engage in a foreign war, and a corollary to this ideal is the present reluctance to admit the thought of a new American expeditionary force on European or other foreign soil. Aid to the embattled democracies "short of war" was another ideal, and many American citizens consequently circulate with blinders on, refusing to admit that the ground has shifted. In this instance not only has the procedure become impractical, but the ideal itself is gradually proving untenable. The combination of a specious ideal with emotional involvement and motives of personal interest is thus a sure prescription for fallacious public opinion.

The problem of combining a stable social organization with a practical volume of individual opportunity is perennial, but the means of solving this problem inevitably vary. For any human problem is eternal, but human solutions, being at best mere expedients, are only temporary, since time shakes the material and psychological bases on which these solutions are set, even though the ideals behind the solutions remain fixed.

We therefore ought not, I think, to be so simple as to persuade ourselves that there will be any universal finality about the solutions reached after this war. Hence the slogans chosen to express its aims might well be a little less than categorical. It is perhaps permissible for a propaganda agency or a publicity man to talk glibly of "making the world safe for democracy" or fighting "a war to end war." The former Allies made the world temporarily safe for British and American democracy, but by failing to provide the Germans with the opportunities to which Professor Whitehead referred or to realize that, as he reminded us, there can be "no *single* world-wide solution of the social problem," they managed ultimately to jeopardize practically every other previously existing or freshly-created democratic structure. The manifest result has been a decline of confidence in democracy and a tendency to disparage any sort of freedom as against security, even when combined with loss of free speech and self-government.

Professor Whitehead wisely pointed out that "history is essential for the direction of action," but that "its naïve application is very dangerous" because "the old phrases are misleading." This I take to mean that the wisdom of knowledge is not always coupled with originative or inventive imagination, so that it is a human propensity to yearn for the recreation of the *status quo ante*. It is, however, encouraging that the statesmen of the dispossessed nations who are now passionately discussing their various problems show little disposition to be fettered by concepts which the past has proved to be faulty. For the future of Central and Eastern Europe they are, in fact, eagerly debating various types of federation, and thus wisely working to satisfy Professor Whitehead's call for coordinated groups.

On the other hand, we may talk eagerly of some ultimate form of Central European or Danubian federation. But almost superhuman wisdom and patience will be required to reconcile national aspirations and jealousies which will be revived as soon as some prospect of liberation appears. Statesmen who regulated the destiny of these countries before the catastrophe may not necessarily be possessed of sufficient ingenuity to master new conditions, and those patriots who have withstood the rigors of enemy occupation may not enthusiastically accept the authority of those of their luckier fellow-citizens who managed to spend the war period in the precarious comfort of London and New York. The most zealous efforts of leaders in exile must be directed toward understanding and interpreting the sentiments of their compatriots under subjection in order to present the latter's needs and desires accurately when restoration becomes possible. Countries lately occupied will have to arrive at some degree of understanding with neighbors who not only were not occupied, but even, on grounds of national interest or cruel necessity, may have been forced to live in accord with the aggressors. The solution for Central Europe lies, not in clinging to points of conflict, but in removing them by common understanding and concession.

However baffling these tasks are, they must be faced with determination and imagination by men ready to reject outworn tradition and to combine the lessons of the recent past with rational ideals of a better future in the creation of a peace of some duration. It is vital that no settlement after the present war should be vitiated either by the dire influence of remote historical events or by the perpetuation of more recent sources of embitterment. The crying need is for a spirit of healthy compromise, so that equal rights and opportunity may be established for Central Europe once the most dangerous points of contact between German and Slav are removed.

Such a rational spirit of compromise does not, by any means, preclude a decent respect for the problem presented by long standing German areas of colonization or regions of recent German infiltration in districts where the German element is surrounded by a majority of different culture and language. The Nazis themselves have not refrained from drastic measures of resettlement and transplantation to regulate such situations in their own interest, and they have quite openly not only declared, but also put into practice, their deliberate intention to wipe out the Slavic intelligentsia of Poland and Central Europe and to turn their Slavic subjects into a class of agricultural and industrial helots. In any peace settlement, whatever German action has been taken toward the realization of this dastardly project deserves the most ruthless liquidation, including removal of German minorities and the settlement elsewhere of such German immigrants as have been purposely introduced to form the nucleus of a new ruling class. This process similarly entails the removal of German population from areas historically productive of repeated international collisions, particularly the Baltic coast from Danzig to Memel and its hinterland. It does not mean, however, that these transplanted groups should be pushed back into an overcrowded Reich, but rather that, in compensation, appropriate colonial areas should be ceded to Germany which will absorb and employ its excess population, thus obviating the chances of its subsequent violent expansion at the expense of any neighboring European state.

But the lessons of the past go further still. The causes of the present war may be summed up in the fateful triad of revenge, strategy, and nationalism. If there is any outstanding conclusion to be drawn from the experience of the last twenty years, it is that setting up a series of economically weak national states solely on the basis of romantic ideals, popular traditions, and strategic aims is no guarantee of peace. To bolster up their weak budgets or to favor local industry, such states erect tariff barriers which prevent the normal flow of commerce and exchange on which their very life depends. If their territories contain linguistic minorities, the latter are discriminated against in business and politics until they seek support from the nearest large state to which they are akin, and eventually provide that state with a natural pretext for intervention. In order to counterbalance their more powerful neighbors or checkmate some adjacent state with good diplomatic connections, these small states unite in ententes and alliances which become the pawns of international politics, and give the statesmen of these minor organisms a chance to assume positions of influence for which they may not be qualified by experience or vision. But with the progressive industrialization of the world and the need of reapportioning both essential raw materials and export markets, there are enough problems confronting the major nations in their dealings with one another without the additional risk of becoming embroiled over the petty aspirations, mistakes, and quarrels of these minor units.

In their own interest, therefore, such small states must inevitably resolve to combine into some form of federal organization. But such a federation cannot live and thrive unless it rests on the enthusiastic support of the masses, who need to be convinced that they are going to get a square deal from a government in which they have a direct stake through universal suffrage and graduated representation. We all talk glibly of democracy, and any average American knows well enough what he means by it: no vague abstraction but representative government, the secret ballot, unrestricted popular education, freedom of speech and worship, equality of opportunity in proportion to a man's capacity, absence of galling government restraints upon a man's private life, the state created for the service of its citizens, not as a cruel master of the individual's work and brain—in simple terms, precisely what one breezy Westerner called "the privilege of speaking one's mind and eating regularly."

Yet it is an open question whether the same definition would always stand when democracy is translated to Central Europe. Democracy does not mean government by an oligarchy of army officers, landowners, country squires, industrialists, or intelligentsia, nor does it offer license for the impulsive activities of small political parties, each too doctrinaire to make concessions to its rivals or to do more than form a temporary part of some short-lived parliamentary majority. For the resulting inefficiency of the whole governmental machine is directly paid for by the declining prosperity of the masses, who then become the easy prey of discontent and of hostile propagandists from right or left. The essence of democracy lies in its permanent obligation and capacity to correct and reform itself. No great institution becomes static unless it has begun to decay, and if a democratic nation does not remedy its own defects, hostile ideologies will use them as effective weapons against it. A federation of this nature, then, must not only be economically sound, but it must also feed on a healthy popular loyalty.

Finally, however bitter may be the resentment felt by the dispossessed nations against the Germans and especially against the present masters of the Reich, it may be set down as axiomatic that, even though certain transplantations of German minority groups appear imperative, a generally punitive peace settlement should be ruled out as opposed to the common interest of the modern world. Every devotee of democracy resents German pretensions to superiority over the Slavs and, conversely, no peace can be enduring which reduces eighty million civilized people to a state of political vassalage. It is likewise impossible to reverse the current of history entirely by partitioning a homogeneous nation now accustomed to unity. Nor can peace be restored if such a nation is deprived of adequate trade outlets or raw material supplies. If a virile nation is barred from colonial expansion, it will expand at the expense of its immediate neighbors: hence certain colonial readjustments are vital. To speak of annihilating such a nation is futile and barbarous. It was Masaryk himself who said, "We often confuse hatred for another nation with love for our own." As soon therefore as the Nazi system reveals its essential weaknesses under the pressure of ultimate reverse or defeat, the younger German generation, now so devoted to it, must immediately be given concrete proof that democratic ideology is actually superior to the false philosophy for which they have been making so many useless sacrifices. At this moment we may not foresee exactly what form of government is best for the German nation. But whatever German government is set up after a Nazi debacle must not be paralyzed by galling restrictions and a sense of inferiority.

These are some general and practical reflections inspired by Professor Whitehead's paper. As scholars we must think on these things and make our conclusions known, lest the adjustment of critical problems is left by default in the hands of those louder-mouthed and less informed.

DISCUSSION OF PROFESSOR WHITEHEAD'S PAPER

BY HANS KELSEN

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Any discussion of post-war problems is possible only under the presupposition that the United Nations will win the war and that they will succeed in destroying national socialistic and fascistic régimes, as well as military dictatorships, where-ever they appear in Europe or Asia. Should this not be possible, then there is no hope for this better world which we have in mind when we speak of post-war problems.

In our discussion, however, we will not proceed from this but from the other possibility, the realization of which we fervently hope for: the victory of the United Nations. The new world order to be established shall be a community of States within which war will be excluded; a community the prosperity of which will be guaranteed by a permanent peace, "a peace which will afford to all nations the means of dwelling in safety within their own boundaries, and which will afford assurance that all the men in all the lands may live out their lives in freedom from fear and want." (Point 6 of the Atlantic charter.)

Such an order is possible only under two fundamental conditions. First: there must be, as far as possible, political and economic homogeneity among the states forming the community. There is little reason to expect communist or state capitalistic states and states with a liberal economic system to exist side by side, even in a fairly loose international organization, as to expect democratic and autocratic states to combine in an enduring union. Second: a satisfactory regulation of the territorial relations of the states forming the community is imperative. This kind of regulation is possible only if it is conducted as extensibly and honestly as possible according to the principles of the right of self-determination of the peoples. Where minorities are unavoidable, they are to be organized as entities with constitutional rights. The treaty establishing the international community will grant them the status of personality in international law, so that they will have the right to call upon an international Court in case of the violation of the provisions for minorities.

As far as the first condition is concerned, a great difficulty arose when the Soviet Union became a full Ally of Great Britain and the United States of America in the war against Germany and Italy. We must reckon with the necessity of admitting the Soviet Union into the new international community, and we cannot expect that the Soviet Union, especially after a victory in which she had a great share, will abandon her communistic and authoritarian régime. However, this difficulty is perhaps not so unsurmountable as it seems at the present time. On the one hand, the economic system of the Western Powers has a clear tendency towards state capitalism, and on the other hand, a victory of the democratic states will strongly influence the political system of the Soviet Union, whose written constitution already has taken on a democratic character. It will only be necessary to conform the political practice in the Soviet Union to the wording of its constitution.

Much more serious, however, are the difficulties which confront the fulfillment of the second condition, namely: the principle of self-determination of the peoples, especially "the right of all peoples to choose the form of government under which they will live" (Point 2 of the Atlantic Charter). It is almost impossible to found the peace on this principle. Of course, the peace treaty will immediately restore Norway, Denmark, Belgium, Holland, Luxemburg, Poland, Czechoslovakia, Yugoslavia, and Greece as independent states in full accordance with the free will of the peoples concerned. These peoples will undoubtedly reestablish their democratic constitutions, or enact such where before the war more or less fascistic elements prevailed, as for instance in Poland and Greece. But the major part of Europe offers no guarantee that its peoples will voluntarily and spontaneously return to democracy and peaceful cooperation with the other peoples. Let us constantly keep in mind that there exist in Europe eighty million Germans, more than forty million Italians, twenty-six million Spaniards, fourteen million Rumanians, thirteen and one half million Hungarians, who have lived for years under totalitarian régimes. Especially the youth of these countries, educated by national socialistic and fascistic teachers, does not know the ideal of democracy and international peace. Let us not forget that Hungary, Bulgaria, Slovakia, Croatia and Finland are now fascist states, or are under the influence of Germany and Italy, and that, last but not least, a great part of the population has, rightly or wrongly, lost its faith in democracy. As far as Japan is concerned, we all know that it is and has been, for many years, under a military dictatorship and that its younger generation is completely alienated from democratic ideas.

Immediately after victory, it will not be possible to organize this better world for which we are hoping. A transitional period will be necessary, characterized by the following facts: complete disarmament of all states now under national socialistic or fascistic régimes or military dictatorship; political and military control of these territories exercised by a body of representatives of the United Nations, above all in order to win the population of these countries for democracy and international cooperation, and to educate their youth for these ideals. No illusion is more dangerous than to assume that these Germans and Italians, these Spaniards, French and Rumanians, these Japanese, (more than two hundred million people) are democrats and pacifists, and that only their dictatorial masters prevent them from having the same political organization as this country or Great Britain.

How long will this transitorial period last, and which is to be the political form of the Union which finally may be established? The first question cannot be answered now. Everything depends upon circumstances which cannot be foreseen today. As far as the second question is concerned, two different plans are suggested: one is to reestablish the League of Nations, the other to create a completely new international organization. The difference between these two plans is, however, not so great as it might appear at first sight. For, should the League of Nations be revived, it could never be the old, it must be an entirely reformed League of Nations. And if a new international organization is to be established, the lessons which can be drawn from the breakdown of the old League will be indispensable for building up the new community.

The decisive question as to the constitution of the new League refers to the degree of centralization which shall and can be realized in the law-creating and law-applying function of the new community. It is the question whether the international community shall or can have the character of a Federal State or only of a confederation of States. There is no doubt that the aims of the intended organization would be achieved in the best and most effective way if this community would be organized as a Federal State; that means the establishment of a World Parliament and a World Administration which is, of course, incompatible with the sovereignty of the member states of the Union. On the basis of our experiences with attempts of creating international organizations, the idea of a World Federal State must be considered—this is my personal opinion—a utopian scheme. Even if such a Federal World State should be desirable, it is, seen from a realistic point of view, quite unlikely that within a reasonable time great powers like the United States of America or the British Empire will unite with dwarf states like Denmark, Norway or Switzerland, that republics and hereditary monarchies will from one day to the next give up their sovereignty, will found a Federal State, will submit their own governments to a World Government in which all the members participate. It is more than likely that this aim, if one accepts it as such, can be reached only in various stages. From the political point of view, the only serious question is, *what is the next step on this road to be taken with a view to success?* Obviously, it can at first only be an international Union of States, a confederation of States, not a Federal State that one should set up. It can be only a confederation of States, and not a Federal State, if the new community of states shall be created by an international treaty concluded by free and democratic governments and not by unilateral coercion exercised by a victorious power. Such a Federation of States is not incompatible with the existence, within its framework, of closer and more centralized unions of single member states. Such a closer union may be established especially by the United States of America, Great Britain and some others of the United Nations, and must be established if these states accept the responsibility of a political control of the vanquished countries.

As far as the constitution of the wider League is concerned, the breakdown of the League of Nations has furnished us a valuable experience. One of the most important, if not decisive, causes of its failure was a fatal fault of its construction, the fact that the authors of the Covenant placed at the center of this international organization not the Permanent Court of International Justice, but a kind of international administration, the Council of the League of Nations. The Covenant placed the Council, not the Permanent Court, at the center of its international organization, because it conferred upon the League not only the task of maintaining peace within the community, by settling disputes and by restricting the armament of the member states, but also the duty of protecting them against external aggression. This protection of member states against external aggression is possible only if the government of the League disposes of an armed force, if the League has its own army, navy and air force. Such a centralization of the executive power means the establishment of a Federal State. Because it was impossible to organize the League of Nations as a Federal State, the League failed completely in its duty to protect the member states against external aggression. The experiences of the League of Nations show that it is necessary to make a clear distinction between the maintenance of internal peace within the League, and protection of the members against external aggression, and that it is hardly possible to fulfill the second task by the specific means at the disposal of a universal international organization embracing many different states. As long as it is impossible to constitute this union of states as a Federal State, it seems to be more correct to limit the task to the maintenance of internal peace, and to leave protection against external aggression to political alliances between the member states. To maintain peace within the international community, its constitution should try to establish the strongest possible guarantee within the compass of international law: the obligation of the member states to submit all their disputes without exception to the *compulsory jurisdiction of an international court* and to execute in full good faith any decision of the court. That means that the members of the League agree to *abandon the use of force* in their mutual relations (Point 8 of the Atlantic Charter), except against a member which in disregard of its obligations refuses to execute a decision of the court or resorts to war or reprisals against another member, without being authorized by a decision of the court.

If the treaty constituting the international community does not establish a central executive power, an army, navy, and air force of the League independent from the armed forces of the member states—a central armed force at the disposal of a central government—the decisions of the international court can be executed against a member state only by the other members of the community, if necessary by the use of their armed forces under the direction of an administrative organ, such as the Council of the League of Nations. The Covenant of the League may determine the size and the organization of the armed force which each member state has to keep in readiness to execute the collective sanction according to the orders of the Council. The Council may be authorized by the Covenant to appoint an organ whose function should be to control the military obligations of the member states and, if a military sanction is to be executed, to appoint a commander-in-chief of the League. But the Council of the new League should be an auxiliary organ of the Court. The fact that its task will chiefly be to execute the decisions of a court, will facilitate considerably the composition and particularly the procedure of this administrative organ, especially as its decisions must be adopted according to the majority-vote principle.

A new League of Nations whose central organ was to be an international court with compulsory jurisdiction would constitute an extraordinary progress in the field of international organization. It would be the technical realization of an idea which the Kellogg Pact first tried to put into operation: the elimination of war as an instrument of self-help. The Kellogg Pact could not succeed because it pursued its end with technically insufficient means. The League here proposed would be an intermediate stage between the old League of Nations and a future World Federal State with a world government; an intermediate stage which is inevitable in the natural evolution of international law. The next step, not the last one. After we have succeeded in establishing an international community uniting the most important states of the world under a covenant instituting compulsory jurisdiction, and after this political system has worked successfully for some time, we can try to make a further step, we can hope to succeed in organizing a centralized executive power, a world police, and later perhaps a world administration under a world parliament.

As far as the economic purposes of the new League are concerned, its constitution must contain certain provisions which guarantee to the members of the League the right "of access, on equal terms, to the trade and to the raw materials of the world which are needed for their economic prosperity" (Point 4 of the Atlantic Charter), and secure for all members "improved labor standards, economic adjustments and social security" (Point 5 of the Atlantic Charter).

But I would like to lay stress upon the fact that, contrary to a wide-spread opinion, it is not the economic element which determines the political one, it is the political element which determines the economic one. If the history of the last decades has taught us anything, it is the primacy of politics over economics.

It is a political task to win the war; it is a very difficult task, but even more difficult will it be to organize the peace.

II

SOUTH AMERICA AND THE WAR

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South of the Rio Grande, there are twenty Latin American republics. They contain an area larger than that of Canada and the United States. They have one hundred and twenty-seven million people, only a few million less than the United States. However, the productive capacity of the people of Latin America is not as high as that of the people of the United States and Canada, chiefly because of the greater mechanization of the latter two countries. Nevertheless, the people of Latin America can play and are playing a very significant part in the war efforts of the United Nations. Though these countries have many manufacturing regions and industries, they are primarily producers of raw industrial materials and foodstuffs which are in great demand principally since the loss of areas in southeastern Asia.

The impact of the present war on Latin America has been terrific, to say the least. Of course, you all realize that the influence of the war on Latin American nations has not been as great as it is on the occupied countries of Europe and Asia—countries that have completely lost their economic status and their political and personal freedoms as well. All the people of Latin America feel the impact of the war. These countries have lost a considerable share of former markets for their products. The people realize as the war progresses that victory for the Axis would also mean for them the loss of political and personal freedoms.

In nearly every aspect the influence of the present war on Latin America has been different from that of the first World War. During the first World War the shipping situation did not become as critical as it is at the present time. There was little German organized activity in Latin America, whereas today Axis propaganda activities have been well organized and have penetrated most sections of Latin America. In the last war Latin American countries lost a relatively small proportion of their European and Asiatic markets for industrial raw materials and foodstuffs. Today these markets are completely lost to those countries, because of the effectiveness of the British and American blockades. Despite the effectiveness of the Axis submarine campaign, the United Nations still control all the shipping lanes to Latin America.

The Shipping Situation:—For cooperation in the war effort Latin American nations need shipping and need it badly. All the large merchant fleets of France, Italy, Norway, The Netherlands, and the small merchant fleets of several other continental European countries no longer serve Latin America. Neither does the large Japanese merchant fleet. Much of the British merchant fleet has been withdrawn. Before and after the attack on Pearl Harbor, most of the United States and Canadian passenger vessels, serving Latin American countries, were taken over by the Navy and Army. However, there is still a large freight tonnage serving this area. Latin America has sufficient tonnage to carry only a small proportion of the commodities it can supply. However, authorities state, that despite the submarine campaign, the shipping situation will improve. Now that the people of Latin America realize that civilians in the United States must get along without many commodities, they do not feel so badly about their inability to secure consumer goods formerly obtained by means of foreign shipping.

Axis Activities:—Less than a year ago a rather important government official in Washington stated that Axis activities in South America were not well organized and would not amount to anything. Recent events have proved that this official was uninformed of the situation and that he was entirely wrong in his statement.

Conservative estimates place the number of Germans in Latin America at 3 million; the number of Italians is several times that of the Germans. The Japanese in Latin America total about 330,000. Germans are concentrated chiefly in Brazil, Argentina, and Chile; the Italians chiefly in Brazil and Argentina; and the Japanese chiefly in Brazil and Peru. However, Axis officials and propaganda agents are present in small numbers in all areas.

Far more than the German and the Japanese, the Italian colonist has been assimilated in the countries where they have settled. Most of these Italians do not want to have anything to do with the Fascist program in Italy and the greater program of the Axis powers. Italian propaganda agents and officials have not been able to organize the Italian population. This situation, however, is not true with the Germans and the Japanese.

During the first World War the large numbers of Germans in Brazil, Argentina and Chile did not become disturbing elements for the governments of those countries. Though some of these countries took up arms against Germany, the settlers gave no serious trouble. However, the situation of these Germans today is not comparable to that in the last war. The Nazi officials and agents have organized all Germans. According to the theory of the Nazis, all pure Germans and also all Germans of mixed stock are still German, no matter how many years they have lived in Latin America and no matter what intermarriages have taken place with non-Germans. The German organization is centered in the embassies. Without exception, German embassies have a larger personnel than other embassies. In some centers, German personnel is greater than that of all other embassies combined. In Buenos Aires, the German embassy has 150 persons as against 30 for the British. That in Santiago numbers 40 persons as against 17 in the American embassy. In all Latin American countries the organized Nazi party has been outlawed. However, often in the same building with the embassy, are the offices of German Beneficent and Cultural Societies, which have taken the place of the old Nazi party organization. In addition there are many hunting clubs, skiing clubs, church clubs, etc. Through the embassies and these organizations, all Germans in Latin America are enlisted in Nazi propaganda activities. In organizing the Germans, officials have used persuasion and force. Persuasion has been eloquent; force has been effective. All of these people are under the direct control of the German Foreign Office. Their names are card indexed and classified in Berlin.

Funds for Nazi activities have come from several sources. Members of societies are assessed for 10 per cent or more of their income. German firms and banks pay their toll. Large sums of money have come directly from Germany. Ostensibly, funds are collected for charitable purposes, for Winterhilfe and for relief of poor Germans in Latin America. However, no accounting has been given. Expenditures of these embassies are out of all proportion to German connections and business transacted. In 1940–41 the German embassy in Buenos Aires spent 5,980,000 pesos, in contrast to 1,830,000 pesos spent by the British, during the same period. Investments and business of the British in Argentina are more than 100 times those of the Germans.

With characteristic thoroughness, the Nazis have utilized all means of spreading propaganda. They have used the postal service, press, movies, radio, German schools, churches, and airlines; they also have put pressure on national leaders and minority parties in order to overthrow governments not in favor of the Axis program. Sufficient time is not available for a detailed analysis of the various propaganda campaigns. I should like to discuss briefly two types of activities:

German Mail Campaign:—A well organized German mail campaign floods the various countries with books, pamphlets, letters, and postcards. Cards and pamphlets are widely distributed, not only to the Germans, but also to a large mailing list of influential sympathetic citizens. This past summer, I saw in Lima and several other cities, a children's Spanish edition of the Life of Hitler. Early last August, I was in Buenos Aires, when the Argentine officials impounded the sixty-seven pieces of supposed personal baggage of Ambassador Von Thurmann, which had made its way to Argentina by way of Japan. When searched, it was found that the baggage was not personal, but that it consisted almost entirely of propaganda literature, done up in small packages with detailed instructions as to where to place the different packages, so as to be most effective. In the same baggage, was found at least one high-powered radio sending set. Obviously, Von Thurmann did not get this baggage. The newspapers in Buenos Aires reported, that on the afternoon the police impounded the baggage, Von Thurmann was seen in his backyard burning huge piles of waste paper. Until recently, the special air mail edition of the Frankfurter Zeitung has been sent by air mail to an unknown number of first citizens throughout several South American countries. In July 1940, postal authorities in the Misiones territory of northern Argentina averred that 95 per cent, by weight, of all the mail handled in the territory was German propaganda.

German Pressure on National Leaders:—The German industrialist, merchant, and banker, as well as the personnel of the embassies, associate with the national leaders in the different countries. Nazi pressure on politicians ranges all the way from cajolery to bribery. Decorations to army officers, free trips to Germany for generals and politicians, academic awards for scientists, scholarships to German universities, are gifts that have been presented with such grace that the word "bribery" would appear rude. They win support by citing German successes, reiterating the certain victory of Nazi armies, and by emphasizing the fact, that those countries had nearly half of their foreign trade with continental Europe before the war, and will need the cooperation of German-dominated Europe after the war.

Nazi agents stir up trouble between various factions in the governments. In several instances, Nazi activities have been significant in the attempted *putschs* to overthrow governments in order to set up new governments in complete sympathy with the aims of the Axis powers. In May 1940, investigators in Uruguay discovered a German document—a detailed military plan to seize Uruguay, to eliminate troublesome citizens, and to make the nation an agricultural colony of the Reich. The congressional investigation, which followed, proved that the Nazi Party in Uruguay had branches and agents all over the country and collected toll from the members by persuasion and force. The Nazi organization had supplies of rifles, machine guns, ammunition, and a well-organized bicycle corps. Like an earthquake, the disclosures shook the Baldomire Government of Uruguay to its very foundation, but the government weathered the shock, broke up the Nazi Party and arrested, tried, and deported eight of the accused men.

Disturbed by rumors of German activity in the territory of Misiones, the Argentine Government in July 1940 ordered an investigation. Nazi headquarters were raided—50 machine guns, 3,500 rifles, and much ammunition were discovered and sent to the national arsenal in Buenos Aires. These revelations stirred up public demand for action. Since then, numerous government investigations have uncovered subversive Nazi activities in several other provinces of Argentina.

Plans for the *putsch* to overthrow the Bolivian Government last July failed completely, as did also the attempted *putsch* in Paraguay less than a couple of months ago.

Japanese in Latin America cooperated with the Germans in making propaganda and in preparing for the attack on the United States. Only recently, the Congressional Committee, investigating aviation conditions in South America, discovered that six Messerschmidt planes were recently flown into Colombia by Japanese pilots. The planes and pilots later disappeared on German plantations in Colombia. The same Committee learned that the Japanese had secretly stored 8,000 tons of dynamite at Medellin, Colombia, within easy flying distance from the Panama Canal. They also discovered that Japanese and Nazi agents had established several secret air bases in Colombia, chiefly in connection with German plantations. This past summer I saw two of these air fields in remote sections of southern Colombia. During the past two weeks the Brazilian Government has uncovered a well organized plan of Japanese officials and Army officers to overthrow the Brazilian government upon receiving orders from Tokyo. This *putsch* like several of those of the Germans has been nipped in the bud.

Accomplishments to Date:—In the past two years much has been done to accomplish hemisphere solidarity and to obtain complete cooperation by Latin American nations in the war efforts of the United Nations. Some of these accomplishments have been achieved so quietly that many people do not appreciate what has happened and do not see the full significance of them.

Axis Airlines in Latin America:—The Germans were the first to introduce commercial airline service between parts of South America. On September 30, 1939 German and affiliated companies in South America had 25,700 miles of airlines. The network connected all South American republics. While many of these airlines were commercial in character, others were extended to remote places of the continent for strategic purposes only. Many airports were laid out on a more generous scale than is required for commercial use only. The lines have been operated without regard to profit. In March 1940 the Germans secured a license to extend a line from eastern Brazil to the far northern boundary on the French Guiana border. There are few inhabitants in that section and little or no trade. The northern route offered opportunities for checking steamship movements in the Atlantic. The Brazilian Government soon cancelled the charter for this line. Between September 30, 1939 and September 30, 1941, the mileage of Axis lines in South America decreased from 25,700 to 14,480. On the other hand the lines owned and operated by United States interests increased in the same period from 18,460 to 33,520. In the autumn of 1941 not a single Axis line existed in Venezuela, Colombia, Ecuador, Peru, Bolivia and there was only one connection with Chile. Some of the lines in Brazil had been taken over by the Brazilian Government. Late in December all the German and Italian lines were grounded by the Brazilian Government. Services on these lines have been duplicated by government lines or subsidiaries of the Pan-American Airways. Even the Italian trans-oceanic operations have been replaced by a new Pan-American Airways service across the South Atlantic to Lisbon. No Axis plane flies within, or connects with, any portion of the Western Hemisphere.

Blacklisting of Firms:—Last year the United States Government discovered a considerable leak in essential war materials to the Axis in Europe through firms in Latin America. For example, Germany obtained platinum from Colombia as late as early 1941. Likewise, as recent as late in 1941, Japan obtained block mica, a very strategic material, from Brazil and shipped it by air to her Axis partners. Consequently, the United States has placed more than 4494 Axis firms in Latin America on a blacklist. Almost without exception, Latin American countries have cooperated with the United States in enforcing the blacklist, despite the fact, that they are not legally required to recognize our regulations covering individuals and firms acting in the interests of Germany, Italy, and Japan.

Freezing of Funds:—Early in the war, in order to curb activities of the Axis agents, United States began to freeze the funds of occupied countries. Last summer the United States froze all Japanese funds in this country. Following the lead of the United States, most Latin American countries have frozen all funds of occupied nations and Axis powers. Taken together, the freezing of funds and the blacklisting of firms has put the finishing touches on all German, Italian, and Japanese trade activities in the Americas as long as the war lasts.

Trade in Raw Materials:—Even more significant accomplishments have been achieved in the field of trade and sources of raw materials. The British and American blockades have completely cut off markets which formerly took about half of the total exports of Latin America and regions which supplies essential manufactured goods. The loss to Latin American nations in exports alone totals more than one half billion dollars. Of course, the loss has not been equally felt throughout Latin America. The Caribbean nations have suffered least because the United States has had a dominant position in their trade—both exports and imports. Argentina and Uraguay have suffered most because their surplus agricultural products compete with our own. At no time has the United States accounted for more than 15 per cent of the total trade of these two countries. However, increased purchases by the United States have relieved considerably the financial distress in many sections, even to some extent in Argentina and Uruguay. In 1940, we purchased from Latin America one hundred fifty million dollars more than in 1938. In 1941, we purchased more than five hundred million dollars over the 1938 level. In other words, for Latin America as a whole our purchases have largely offset the loss of European and Asiatic markets.

Our increased purchases include many critical and strategic commodities. The Metals Reserve Corporation, a government organization in Washington, has contracted to take all of the surplus copper, tin, vanadium, tungsten, bauxite, antimony, manganese, industrial diamonds, mica and other essential minerals. In 1941, we purchased the entire wool clip and surplus accumulated stocks of wool in Argentina and Uruguay. The Latin American governments have cooperated with the United States by agreeing to deny all these essential war materials to the Axis powers and by pledging virtually their entire output to the war needs of the United Nations.

The possibilities of Latin America in supplying essential war materials have only begun. Of a list of about 40 materials essential to the production of military equipment, Latin American nations supply considerable quantities of 28. Among these are many of the critical and strategic minerals. The output of these in Latin America can and is being increased rapidly. Shipping facilities will be made available to move these products to the factories of the United Nations. Latin America can also supply large quantities of certain strategic fibers and other materials, such as wool, tanning materials, coconut shell char, and hides and skins. On the other hand, we cannot look to Latin America to supply us with large quantities of certain products formerly almost entirely purchased in southeastern Asia. Such things include jute, kapok, Manila hemp, quinine, silk, opium, and rubber. Much has been written recently about the possibility of obtaining some of these materials from Latin America. There is no production of jute, Manila hemp, silk, and opium in Latin America. However, for some uses other fibers of Latin America may be substituted. Sufficient coconut trees are growing in Latin America to supply us with coconut shell char and also with a considerable fraction of our requirements for coconut oil. From the millions of wild kapok and cinchona trees growing in the tropical rain forests of Latin America, we can by the organization of a gathering industry obtain kapok fiber and quinine in considerable quantities. Despite rather optimistic estimates by several officials, the forests and plantations of Latin America cannot supply us with sufficient rubber to make up for the loss of the supplies from Malaya and the Netherlands East Indies. There are only two rubber plantations in Latin America. They can produce only a few thousand tons of rubber. With time and much money for the organization of a gathering industry from the wild trees, we probably can obtain in 1943 about 60,000 tons of rubber from the wild rubber trees. This would be equivalent to less than 10 per cent of our requirements. While many areas are suitable for the production of rubber on plantations, it would take at least six years, much capital, and careful organization to bring new large rubber plantations into production.

Even though we may obtain all that Latin America can produce of the above strategic and critical materials, we cannot get from those countries sufficient quantities for the manufacture of military equipment and at the same time supply normal civilian consumption. However, by largely eliminating civilian consumption of many products, the United Nations can go a long ways toward obtaining from Latin America sufficient materials for the manufacture of military equipment. Whether we like it or not civilians can and will for the duration get along without many commodities formerly consumed in large quantities. This is true not only of the people of the United States but also those of the Latin American countries. The realization by Latin Americans that the people of the United States will have to deny themselves of certain pleasures and luxuries has improved considerably inter-American relationships.

Capital:—To obtain larger quantities of the above materials from Latin America will require much capital from the United States. It is fairly well known that for a long time Latin American countries have not had the capital with which to develop their resources. Even before the war, billions of foreign capital had entered Latin America. While those nations have tapped various sources of revenue, most of them depend upon customs receipts for from one-third to two-thirds of their total government revenue. Both imports and exports are taxed. With the loss of foreign markets and with their inability to obtain imports, these sources of revenue have been cut drastically. Consequently, in the present crisis the need for foreign capital in Latin America is greater than ever. Since the outbreak of the war, Germany, Italy, and all the occupied countries of Europe have been completely cut off as creditor nations. In order to prosecute the war, the United Kingdom has had to call in reserves of both private and government capital and credits in foreign countries. Consequently, the United States is the only large source of capital for Latin American enterprise and loans. In September 1940, Congress allocated one half billion dollars to the Inter-American Bank for the development of Latin American resources and the orderly marketing of the products of those countries. Under these regulations, sizable loans have been made; one hundred ten million dollars to Argentina; three and one half million dollars to Paraguay and various sums between these two extremes to other areas. Such capital is being used especially first, to develop facilities which will supply increasing quantities of strategic and critical materials; second, to improve transportation facilities; and third, to develop manufacturing establishments that can produce some of the wares formerly supplied by the continent of Europe.

Though the recent loans and private investments and those that will be made may total hundreds of millions of dollars, they will represent a tiny fraction of the total cost of our war effort. For the material and other aids Latin America can give to our war effort, this capital is well placed even though some of the principal may never return to the United States.

Military Aid:—As a layman, I speak with less authority on questions of military matters than on economic. Nevertheless, a layman with an economic and geographic training is in an excellent position to analyze certain phases of military defense in relation to problems of hemisphere solidarity and the war effort. In the present world, no amount of economic and political planning can achieve hemisphere solidarity without the material equipment for exerting force—without adequate naval, army, and air power and suitable bases for their operations.

Latin American countries have not, until recently, seriously considered the possibility of military attack from Europe. The Monroe Doctrine and the existence of the British and United States fleets have seemed to them adequate guarantee against that possibility. The German conquest of most of Europe, however, with the resulting threat to the British fleet, the fact that the bulk of our fleet has been stationed in the Pacific, and the activities of German agents in certain South American countries have changed the picture, particularly for Brazil, Argentina, and Uruguay. These east coast countries face Africa, and could be threatened from there, should western Africa fall into the hands of the Axis partners. Northeastern Brazil, is only 1600 miles from western Africa.

This is only two-thirds of the distance from northeastern Brazil to Puerto Rico, formerly our nearest naval base.

It is fairly well known that Latin American army and naval facilities are very limited. Altogether Latin American nations have only 111 fighting ships, mostly average, with a total tonnage of approximately 263,000. There is no comparison between the size and equipment of their naval ships and ours. The twelve Caribbean republics together have a naval tonnage of less than 19,000, less than that of one modern cruiser. Yet the Caribbean area with the Panama Canal and Caribbean shipping lanes is a most strategic area. Eighty-seven per cent of Latin America's naval tonnage is in Argentina, Chile, and Brazil—forty-two per cent in Argentina alone. These southern republics have 5 battleships, 7 cruisers, 25 destroyers—with 9 more being built in Brazil—16 submarines, and many smaller vessels. Furthermore, the armies of Latin America are small and poorly equipped.

With these facts as a basis one might assume that Latin American nations could from a military point of view do little, if anything, to assist the United Nations. As a matter of fact this assumption is far from correct. After the attack on Pearl Harbor and the conference of ministers at Rio in January, nearly half of the Latin American countries declared war on the Axis powers; all except Argentina and Chile broke off diplomatic relations. Breaking off diplomatic relations and a declaration of war means putting an end to all Axis propaganda and the arrest and internment of all Axis agents. Most Latin American governments are doing a rather thorough job in this respect. It means that the ports and naval bases of those countries are open to our merchant and naval vessels and closed to those of the Axis powers. It makes available the small naval fleets for policing their own coastal waters. The Caribbean nations have gone one step farther. They have permitted the United States to establish many airplane and other bases within their borders for patrol purposes for the protection of the Panama Canal and the Caribbean shipping lanes from marauding submarines. Though the Latin American nations may not be able to give us great aid directly with their armies and navies, by an open break with the Axis, thus cutting off all intercourse with them, they may contribute greatly to the actual conduct of the war. With the present position of Argentina and Chile, the American nations have not achieved complete hemisphere solidarity and complete cooperation in the war effort. However, pressure is being and will be applied to those two countries until they fall in line with the other nations, thus presenting a solid front against the Axis.

Conclusion:—Most of the Latin American nations realize that economic and political security for them depends upon victory for the United Nations. Because of the success of the Axis powers and the full realization of what the Axis program and Japanese Greater East Asia mean for conquered peoples, the Latin Americans are willingly working to aid the United Nations. They realize fully that the job of supplying military equipment and fighting battles on many fronts falls heavily upon a few of the United Nations, especially the United States, the British Commonwealth of Nations, and the U. S. S. R. By supplying critical raw materials and by eliminating Axis contacts in those countries, the Latin Americans are giving valuable aid for the cause of democracy. Despite minor differences of opinion, the people of the United States should give Latin Americans full credit for what they can and are doing in the war.

III

"VS-300 HELICOPTER"

By Igor I. Sikorsky

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Many of us still remember the first decade of flying when planes were frequently operated from small fields, or even race tracks. It was then expected that progress in the art would permit taking off and landing from still much smaller places. Actually, the development went in the opposite direction and further progress made it necessary to use much larger and better airports than those which were adequate for the early airplanes. This being the case, flying proved to be drifting away from homes, residences and places of occupation rather than moving towards them. The possibility of an aircraft capable of duplicating the performance of a hummingbird that could land in any spot on the earth where it could spread its wings, appeared more difficult than was thought in the early years, even, perhaps, impossible. It became evident, however, that while the fixed-wing airplane would never permit obtaining such performance, yet a good solution of the problem was entirely possible on the basis of a different principle of flying.

The object of this article is to give a brief description of such a mechanical hummingbird, the United Aircraft VS-300 Helicopter, which is the result of a work that was started in 1909, was at times discontinued, then was resumed and finally resulted in the creation of the present aircraft. This helicopter was completed in the Fall of 1939; it made many hundreds of small hops, underwent a large number of developmental changes and improvements; it demonstrated its capability for direct take-off and landing with no forward speed, as well as excellent flight and control characteristics. Finally, on May 6th, 1941, the VS-300 established the world record for endurance for helicopters be remaining in the air for 1 hour, 32 minutes, 26.1 seconds exceeding thereby the previous world record held by Germany. During this entire flight, it hovered above an area less than half an acre.

The success of the VS-300 leaves no doubt that the direct lift machine is here. It might be interesting, therefore, to review briefly the type of service it can render.

The helicopter in general must not be expected to replace or duplicate the service of the vast majority of military or commercial airplanes. The helicopter's place in air travel is to solve a transportation problem that is not yet met by any other means. While it will probably have a limited operating speed of between 100 and 150 miles per hour, yet due to its complete independence from airports, it will prove to be by far the fastest and often the best method of travel for the comparatively short distances that the average individual is usually called upon to go.

For instance, it will cover the average 100-mile journey much more rapidly and more conveniently than any other vehicle of transportation, including its fixed-wing brothers. It will do it more rapidly because the average journey is not from airport to airport, but from home or office to some practical destination. In other words, a 100-mile trip in a 200-mile airplane would require, besides the 30 minutes of flying time, an average of from 30 to 40 minutes of ground transportation at either end, plus the often unexpected delays of making automobile connections, getting under way, facing traffic congestions, etc. This being the case, the 200-mile-an-hour airplane becomes really valuable only for much longer distances, while for trips of 100 miles or less, the helicopter will prove to be much faster, as well as much more reliable and convenient.

Darkness or poor visibility are an incomparably lesser danger or inconvenience to the helicopter than they are to the privately owned airplane. If the driver of a helicopter finds himself in a questionable predicament, he may slow down safely to 30, 15 or 5 miles per hour, just as he would in his car. He may then proceed close to the ground, flying around obstructions or trees and, if necessary, he may land in any place the size of a 50-foot clearing. The spot may be a vegetable garden, a ploughed or muddy field, or a rocky knoll, etc., and in all such places the helicopter would land safely and comfortably.

The number of services that an aircraft with such characteristics could render can hardly be over-estimated. In this tumultuous world, we must unhappily give thought to certain grim aspects. In war, the helicopter will be excellent for communication, for sudden short range bombing attacks, for convoy purposes both on land and on water, for observation, reconnaissance and scouting, for gun-fire control, for liaison behind the lines, for removing trapped or wounded troops, or for depositing troops behind the enemy lines, etc. In government services it would be excellent for airmail over short distances, for carrying passengers and airmail between airports and the post-office or the heart of the city, for crop-dusting, for rescuing persons marooned by storm or flood, or delivering food and medical supplies to them, for coastal patrol and for life-saving under greatest possible variety of conditions.

The facility with which the helicopter may render service under the most difficult circumstances is augmented by its ability to hover directly over one spot for indefinite periods of time. Thus, even if a landing is prevented by heavy woods, surf or other conditions, a rope ladder or basket can easily be lowered to deliver or raise materials, as well as men.

The above-mentioned performances are no longer a question of theoretical speculation because the possibilities of most of them have already been demonstrated with the present light, low-powered, purely experimental VS-300 helicopter. This aircraft has many times been taken off and landed on very small spaces, in backyards, often with some obstruction such as a big tree some 10 feet directly in front of the machine. Repeatedly a man standing on the ground has fastened a load to the end of a rope dangling from the helicopter while the ship hovered motionless above him. It was then lifted into the air and unerringly deposited on a given spot or lowered into the arms of a waiting man. Another demonstration of its ability is that it has often been flown up to a standing man while a suitcase has been placed on board, without the man taking so much as one step, and without the aircraft ever touching the ground.

From these facts, it may be concluded that a successful helicopter is now in existence and that it opens a vast and untouched field in flying. It is now possible to look forward, earnestly and hopefully, to the rapid and final improvements that will bring this type of transportation to the world.

IV

TECHNOLOGY AND HUMAN RELATIONS

By Carleton S. Coon

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Introduction:

Never before, in human history, has a disturbance arisen as great as that of the present war—a disturbance affecting, directly or indirectly, almost every single human being on the face of the planet. One of the automatic reactions to this disturbance has been the effort of political leaders, popular writers, and scientists to determine what is wrong with our system of world relations, that could permit such a disturbance to arise, and what can be done to make sure that it will not rise again, once the battle is won. I assume that we shall, as we must, win it. That is the premise upon which this discussion is based. Some of the most far-seeing men of our time realize that we must solve this problem now, and not wait until the war is over, since its solution is as necessary for the shape of the war as it is for the shape of the peace to come.

The principal difficulty, which has brought this state of affairs to pass, seems to be a lack of planning in human relations during the fabulous twenties and the twilight of the thirties. Planning of this kind was more necessary then than it had been before, because, although few of us may have realized it, one era of history had ended, and another had begun. People failed to realize how necessary it was to provide a basis for equilibrium for the lives of the different peoples of the earth, one which would permit an integration of the mutual relations of mankind as a whole.

Before this time, technological advances could be made without upsetting the balance of the world, because the presence of empty land, or the conquest of technologically inferior peoples, allowed expansion without planning. Once the empty lands had been filled, once the last of the primitives had been killed or packed off on reservations, the pioneering period was at an end, and it was necessary for us to make our adjustments within a contracting, rather than an expanding, universe. In the past we always made our expansions at the expense of simpler peoples, but we can do this no longer since there are no more such peoples to conquer or empty spaces to fill. Any expansion now is a case of dog eat dog.

The only way in which adjustments can now be made is to abandon the age-old, automatic process of trial and error, and to plan them on the basis of the physiological needs of the individual human animal, and a recognition that these needs are the same, whether the animal in question is a modern American, an African Negro, or an Asiatic.

The equilibrium which we must attain is not to be defined in terms of economics alone, but rather in terms of the way in which people get along with one another. One of our greatest mistakes has been to leave the process of adjustment in the hands of the economists and engineers, who, however expert they may be in their own fields, have only a lay knowledge of human relations. They are therefore unable to see the human consequences of the changes that they have themselves instituted. They should not, however, be blamed for this, since they have done their own job remarkably well; the error lies in their belief that because they could build automobiles or float international loans, they were experts in human relations as well.

The results of this fallacy speak for themselves. Every plan, whether for a new world order or for a Treaty of Versailles or for a League of Nations, has to be run by human beings. Its operation involves the emotions of human beings, and their peculiar ways of behaving. No plan works automatically. The usual excuse of the people who tackle these problems in terms of economic or political logic is that they regard human nature, as it manifests itself in human relations, as an extraneous factor over which there is no control, and which spoils the beautiful symmetries of their cloud castles. They say: "It was all politics," or "it was ruined by graft," not realizing that politics and graft are predictable phenomena of human relations.

The only test of a plan is to see whether or not it works. The excuses made by planners of world orders that did not work, and by unsuccessful international politicians, are as fallacious and self-incriminating as it would be if an engineer, when his bridge collapsed, were to say: "It was a beautifully designed structure, but one can never tell about the strength of metals." Builders of world orders must find out about the properties of human beings in their relations to one another, and this can only be done if we start at the beginnnig and study the physiological basis of human behavior.

The Physiology of Human Relations:

Human relations, as students are beginning to realize, form an essential part of the activity of the human organism, and cannot be separated from this activity any more than the "mind" can be separated from the body. Each human organism, like other animals, maintains what is called an internal equilibrium, essentially similar to the equilibrium of inorganic substances long recognized by the physicists and chemists. This equilibrium is maintained, as long as the organism is alive, through a series of bodily processes, changes in the rates of which we call *emotions*. Emotions may be defined as disturbances in the equilibrium of the bodily processes which are produced by changes in the external environment. They are, in other words, the reactions which occur when these bodily processes try to adjust to new conditions.

Cannon, Bard and others have shown how what is called emotion is made up of the combined effect of changes in heart activity and respiration rates, and in the velocity of the chemical secretion of blood sugar, adrenalin, mecholyl, and other substances. These adjustments are regulated by the autonomic nervous system, which is consequently responsible for maintaining equilibrium when sudden changes take place in the environment, which disturbs the equilibrium, rage and fear responses are set in operation.

These emotional patterns are basically reflex in character. Though we learn to discriminate between stimuli, that is, though we become conditioned by experience, some reaction always occurs in response to changes in stimuli. If these changes are sudden, that is, if we become afraid or angry, cortical control is decreased, and our capacity for adjustment, for fine discrimination, and for carrying out our regular routines, is lost.

In any institution, that is, a family, political group, industrial organization, etc., changes in stimuli are constantly activating the autonomic nervous system and its associated organs of the individuals concerned. These stimuli, affecting each individual, come primarily from other people, and our relationships with people are consequently the principal source of our emotional experiences. These relationships take for the most part the form of routines, to which we become conditioned, and when these routines are interrupted we suffer emotional disturbances. That is why it is so difficult to get people to change their habits in an emergency which has not already affected them personally.

If the contacts which we have with other people and to which we are conditioned occur with a regular frequency, or if the changes which take place in them are quantitatively small enough so that rapid adjustments can be made, the autonomic nervous system maintains the organism in a state of equilibrium. If sudden changes, to which we cannot readily adjust, occur constantly, if equilibrium is not rapidly restored, then the autonomic balance is upset and marked compensatory changes in activity take place. Then the system of relations is upset; people are frightened and angry; they are unable to adjust to others and to accomplish tasks which require cortical control. In other words, they lose their heads. And when they lose their heads they do things that will serve to upset the equilibrium of the people with whom they are in contact, and these people may in turn disturb others, until the equilibrium of large institutions may be disturbed.

The problem of equilibrium in a state is essentially the same as that of peace in the family or morale in an industry. In each case the problem is to organize the technical routines of operation, be they family routines, or political, or technological, in such a way that the equilibrium of individuals is maintained, or, if once disturbed, is rapidly restored before the violent compensatory reaction of fear and rage take place: in simpler words, a state of peace, equilibrium, morale, or whatever you wish to call it is obtained when the individuals within groups can adjust rapidly to changes without becoming afraid or angry or both.

Since the technical requirements of the work or duties of any institution, be it a family, a state, an industrial plant, or whatever, require certain daily, weekly, and other routines, and since the individuals who perform these routines have to learn complex motor habits, the aim of any planning board, or management, whether it be for a button factory or a new world order, which wants to succeed, must be to see that these routine habits can be carried out in times of crisis as well as under normal conditions. This can be done, but only if the individuals of whom the family, the factory, or the world order is composed are not constantly disturbed and emotionally upset. That is why free men work better than slaves, and why a state founded upon justice, equality, and a voice for all is, in the long run, a more lasting and progressive state than one founded on tyranny.

Technology and Human Relations:

It is readily apparent, therefore, that the requirements of the human organism for equilibrium in interaction, which may be called "human nature," are more or less constant, and that in all populations they will vary individually within more or less the same limits. In every population there will be some who are energetic and others who are not; some with the capacity of leadership and others who lack it. Furthermore, as far as we can tell at present, the inherent capacity of the individual for making cortical linkages, which seems to be the basic variable in what we refer to as intelligence, also varies in each population within given limits, and differences in so-called intellectual performance between groups of people may be attributed not to genetic differences but to differences of conditioning.

In view, therefore, of the essential equality of mankind, one is led to ask what is the reason for differences in the complexity of human relations in different societies, why are some people "primitive" and others "civilized," and what bearing has this problem on our problem of establishing a world equilibrium? The answers to these questions are that variations in the complexity of human relations depend on differences in the technological processes by which people exploit their several environments, since the bulk of human interaction, i. e. human relations, is carried out on a technological framework. For that reason the understanding of technology is essential to the problem of planning a world equilibrium.

A few examples should suffice to show how technology, in combination with environment, controls human relations. Let us first consider the technique of water transport. Two French Canadian trappers are paddling downstream in the early summer, from their trapping grounds to the trading post, with a heavy load of furs. One man paddles bow, the other stern; their actions must be synchronized if they are to reach their destination. Thus the technique of canoe paddling determines their mutual relations during the working day in summer; but it determines a number of other things as well. It limits the number of men who can work together at this enterprise; it limits the amount of fur which they can bring down, and the amount of food and other supplies which they can take back in the fall. In combination with their other techniques it limits their relationships with other people, making it impossible for them to take their wives and children along, enforcing isolation on the two of them during the long winter, limiting their interaction with the trading company to a brief period, and their participation in state and church to the same time. Men who live by this and the accompanying techniques cannot build up complex sets of human relations.

Another example may be drawn from the field of manufacturing. In the mountains of Morocco, in the tribe of Taghzuth, the land is too poor to support a large population. Nevertheless there is a large supply of tan bark in the forests. The men of this tribe are mostly craftsmen, and many of them are engaged in tanning hides and manufacturing leather bags to be sold outside. In some instances a man and his sons run a leather-working establishment, and the pursuit of this technique enforces the frequency of events within this segment of a family. The need of buying hides and selling the finished product establishes other relationships with specific individuals. In times when the demand for leather bags is great, the master craftsman will hire apprentices from outside the family, which will mean new relationships, and he may delegate to one of his sons or apprentices the task of selling the bags to jobbers, so that his commercial relationships are thus extended and canalized.

If the average American will consider the techniques which he himself practices, be they metallurgy, medicine, pedagogy, or whatever, he can readily see how his own human relations are determined by them, and how this extends to his relations outside his immediate technical pursuit, as for example to his family. He gets up in the morning, and after interacting briefly over the breakfast table with his wife and children, runs for the train. During the day his time is taken up with relations in other institutions, in which he has been conditioned to a daily routine; if that routine is seriously disturbed he will have had a "bad" day. He meets and must adjust to dozens of persons in different institutions during the day. This wide range is facilitated by his use of the telephone, the automobile, the subway, etc. The more complex technology of his civilization renders his daily routine of interaction correspondingly more complex than that of the fur trapper or of the Taghzuthi leather worker.

Equilibrium in Technological Processes:

In any technical process in which a number of people work together, be it in government, the church, industry, or the family, there are three potential sources of disturbance, as follows. The first is *the inefficient definition and allocation of work,* in which people do not know exactly what they are supposed to do, or what is the most efficient way of doing it. Such technical inefficiencies prevent individuals from making satisfactory relations to one another in terms of the work process. They are unable to develop regular work routines and are constantly upset.

The second is *the maladjustment of personalities in terms of the work process,* where individuals with personalities which they cannot adjust to one another are forced to work together by the requirements of the job. For example, the two fur-trappers who are paddling their canoe must be similar in activity rates, so that they can paddle together synchronously. Otherwise they would become upset, and angry at each other, and their partnership would dissolve. The only way to avoid difficulties of this kind is to get the right man for each job, and this can best be done by an objective study of the physiological properties of the individuals concerned, in terms of the specific job. A military leader, excellent at organization in peace time, might be useless on the field of battle. A McClellan will not make a MacArthur.

The third is *faulty relations between members of different organizations,* as when the heads of the Army and Navy will not speak to each other and thus permit a military disaster; when the members of neighboring countries cannot understand each other and hence develop friction whenever they meet; when the superintendents of factories leave everything to their overseers and have no contact whatever with their men, and many other such examples.

Disturbances of all three kinds can be avoided or eliminated if we understand not only the technological processes concerned, but also the biological properties of the people who practice the techniques. A technique exists only as some human being or group of human beings practice it. You cannot talk of a technique as apart from human relations, as some archaeologists discuss potsherds and bronze axes as if they were living organisms that procreated and evolved without the aid of man; the archaeologist who works in these terms will never make a true reconstruction of history, and the planner, political, industrial, or otherwise, who plans in terms of treaties, bank-notes, or machines without thinking of the men whose relations are determined by these devices will never plan a working society.

Modern Technological Systems:

As we have already stated in the introduction to this symposium, the technological systems of what we may call the colonial or pioneering period in our world history are in the process of replacement. These technological systems were characterized by methods of communication vastly inferior to our own, so that no world equilibrium had yet developed. The world of mankind was broken up into a series of isolated or nearly isolated systems. For example, the United States obtained rubber and rattan from the Malay Peninsula, but the natives of these two countries seldom saw each other and knew little about each other. The same was true of the relations between Argentine beef-growers and the Englishmen who ate the beef, etc.

Within the major systems, by which term we categorize the great, imperialistic powers, the adjustment of individuals was unstable, and equilibrium was attained only through external aggression. The mill-workers of Lancashire could be kept at their looms only as long as British soldiers and merchants carved out new markets for their cotton fabrics in Africa and Asia; and later on Japanese industry was dependent upon Japanese shipping and trade.

Sooner or later, as the frontiers disappeared, these major systems were bound to come into conflict with one another, and since each of them could continue to maintain its former type of equilibrium only by further expansion, the expansion of one would necessitate destruction of others. This process of expansion and conflict has been accelerated by the rapid improvement, during the last two decades, of our techniques of travel and communication, in combination with an increasing efficiency in manufacturing processes, particularly in the field of mass production. We are no longer concerned with partly isolated systems whose relations are carried on at a low frequency in a few channels only. After the last war England, France, Germany, Japan, Russia, and the United States had the choice between a mutual adjustment or an explosion. Attempts at adjustment failed because of their unwillingness to consider the human requirements of everyone concerned.

Inequality in material possessions is characteristic of intermediate stages of technological development. The simplest food gatherers, like the Australian aborigines, are all equal—each man has his flint knife and his handful of spears, each woman her digging stick and her stone for grinding seeds; they could not own more things than these because they could not carry them about with them in their search for food. With sedentary life and improved techniques, the relatively complex relationships which arise between individuals in societies produce the basis for inequality. We are still in an intermediate stage in this respect, but we have made the technological advances which will inevitably bring us out of it, to a third stage in which the distribution of goods can once more be approximately equal. In other words, we have now attained the position in which we can calculate the requirements of our populations and we can look forward to their fulfillment.

These requirements are not concerned with bodily comfort alone, but also with the techniques by which people can adjust to one another most successfully. The widespread use of the automobile in the United States will serve as an illustration. Efficient transportation enables us to avoid a rigid system of routines, conditioned by life in a small circle of relationships; it enables us to interact in a wider and more varied circle. We can choose the friends of our liking from many communities, instead of having to get along with our immediate neighbors, whether they are compatible with us or not. We can move out of the cities and adopt routines more satisfactory to those who cannot adjust easily to crowded urban life. The possibility of cheap airplanes or helicopters in the near future means that this process may be extended even further. It may not be too rash a generalization to make that nations whose peoples are relatively mobile, from the Arabs and Mongols to the modern Americans, have a greater flexibility of adjustment and hence a greater stability, than purely sedentary peasant and urban communities.

It is not only in the field of transportation that modern technological science has provided us with new developments, even since our entry into the war. Great advances have also been made in mineral extraction, metallurgy, and other basic techniques, so that the technological basis for human relations has been potentially extended to an enormous degree; this means that it is now possible, or that it will be when the war is won, to maintain constant relations between people in all parts of the earth; that our problem of timing in world events can be solved, because the technical means are at hand. Once people can be made to realize the significance of these changes and reconditioned from their habitual patterns of behavior, technology has provided and will increasingly provide for that ultimate stage in human democracy, when the peoples of the earth will share alike in its products, and hence differences in their relations to each other will depend upon differences not in race or place of birth or wealth, but in individual personality and attainment.

If, therefore, we plan wisely, and if we strike in time, our conquest of technology should, even in our own lifetimes, bring to the world what we now fight for—universal freedom—that equality of opportunity for all the peoples of the world which we in this country have been promised and have of all peoples most nearly attained.

V

THE NATURE OF WORLD EQUILIBRIUM

By Conrad M. Arensberg

Introduction:

Now that we have seen how technology, acting upon the human organism, conditions the form and extent of human relations, our next task is to determine what structural form these relations take, in other words, how individuals adjust their personalities to each other in institutions.

The importance of technical activities, is not confined to the direct conditioning of the relations of specific individuals. Technology has even broader implications; it controls the ways in which groups of individuals live and work together. The requirements for interaction which it imposes necessitate the mutual adjustment of groups of individuals in such a way that they attain a state of equilibrium.

We have already seen how the physiological properties of the individual himself bring about such a state; but in order for any kind of stability to be maintained, all the individuals with whom he interacts must also achieve a similar state and this can only occur if the relations of all individuals together form a system in equilibrium.

In the performance of any technical activity, where more than a single individual is involved, an adjustment must be developed between the individuals concerned. In the case of the French-Canadian trappers mentioned in the last paper, an adjustment between the two individuals concerned had to occur or else the pair would have been unable to work together and would have had to split up. In more complex technical activities, however, where a number of people have to interact in order to accomplish successfully their technical end, one of the individuals must act so as to secure some degree of coordination between the several persons and the tasks to be performed, if the activity is not to fail completely.

For example, in a Paiute antelope hunt observed in Nevada almost a hundred years ago, the Indians had built a corral of logs at the end of a valley, and had placed clumps of sagebrush in two diverging lines from the mouth of the corral for several miles up the valley. At the appointed time several hundred Indians were stationed at fixed points; some between the clumps and others up on the hills. When the signal was given the men on the hills started beating and yelling and driving all the animals in their neighborhood down the slope; as the animals tried to dart between the clumps of sage-brush, other Indians would jump up and frighten them back, until finally all or almost all of the antelopes, jackrabbits, and other animals had reached the gate of the corral, where the men converged and drove them in.

This antelope hunt required the cooperation of many people, under the direction of a leader, who organized the hunt in the first place, bringing people together from their distant camps, telling each of them where his station was to be and what he should do, and giving the signal to begin.

In our own society we can take almost any example to illustrate this. One of the easiest to illustrate is that of a ship; even on the smallest tramp the technical requirements of operation make it necessary for many men to perform different skilled tasks at the same time, or in ordered sequence. When the ship is about to leave the dock many things happen at once. The donkey men draw in the loading booms; the stevedores march ashore over the gang plank, and members of the deck crew batten the hatches. Down below the chief engineer is watching his dials while the black gang is feeding the furnace, and the oilers are at their stations along the main shaft. Up in the chart room the mate is plotting a course, while the captain talks to the pilot, who has just come aboard. The time has come to shove off. The captain pulls the lanyard for the ship's whistle, and the men below take their positions on the deck. The captain signals to the bos'un, who blows his whistle. Members of the crew draw in the gangplank, and the men standing on the pier cast off the bow lines. Then the donkeymen reel these lines in quickly. A bell rings; the captain has signalled to the engineer—the propellor turns and the ship moves forward and outward. Now the stern lines are taut, and the propellor churns the water; the ship is thus turned so that its axis lies at an angle to the dock. Another signal, and the ship moves astern; the stern lines slacken and are cast off. Now the ship moves forward and steams away from the dock and out of the harbor.

In this familiar scene of a ship leaving port we have an example of a sequence of events involving a number of men who perform separate, specialized tasks in such a way and with such accurate timing that a complex maneuver is executed. In this instance and in that of the antelope hunt, the successful accomplishment of these separate duties in unison can only occur if some one individual's actions serve as the signal for others to perform their parts of the operation. Events such as these occur continually in daily life, and their repetition conditions individuals to the performance of specific technical activities under the direction of specific leaders. These recurrent patterns of ordered action make up the structure of society. These routines are physiological in nature and provide the individual with the basis for his equilibrium. When these routines go wrong; as when the antelope break through the line of beaters or the ship fouls the pier, rapid changes occur in the activity rates of the individuals concerned, and the resultant emotional disturbances can readily be seen.

The Division of Labor and the Complexity of Institutions:

In all human societies there is some kind of a division of labor which the specialization of the men on shipboard will illustrate. It derives not merely from the fact that many techniques in fact require several individuals to perform them, but also that individuals have different capacities to perform different types of work. The simplest example of this differentiation, which is found in all societies regardless of their technological level, is the division of labor on the basis of age and sex. Thus men hunt, fish, trade, and go on the warpath, while women take care of the children and do their housework; children play, adults work, and senile individuals reminisce with each other while basking in the sun.

But within this general division, individuals tend to specialize; one man spends most of his time trading, and another at making weapons for the rest of the group; one woman concentrates on making pots, while another may weave blankets for which she is specially noted. This part-time specialization, due to the special aptitudes of the individual, derives largely from the essential physiological properties of human beings, in terms of the technical differentiation which these simple tasks necessitate.

As people develop more and more complex techniques, a further division of labor takes place. In weaving, for example, instead of the whole process being performed by one person, from shearing the wool to the final process of dyeing, several persons may specialize, one to shear, one to spin, one to weave and one to dye the finished material. Since a specialist is more skillful than a jack-of-all-trades and can, with superior techniques, produce more goods per day or per hour, people who live on such a level have more material possessions than those who lack this kind of division of labor.

As the techniques become increasingly complex, an increase in the division of labor is not the only result; another is the need for more and more supervision. In an automobile factory there is a whole staff of men whose task it is to plan operations and to organize the workmen, as well as to direct them; leadership becomes increasingly elaborate and itself specialized.

In any group of men working together at a task of any complexity, therefore, there must be organization if the task is to be successfully done. This organization must be habitual—that is, the man who is leader one day must also lead the next, and the order of action from director to foremen to workmen, and from department to department, must be habitual and the personnel must be suited by their personalities to their several roles, and conditioned to them as well.

The Organization of Peasant and Urban Communities in the Pre-war World:

Now that we have seen how the complexity of institutions of which societies are composed depends upon the interactional requirements of the technology available to the group, we can begin to estimate what effects the systems existing before the rise of the modern technological age will have on a world order. Even today new and old technical systems face each other throughout the world, and the attainment of a world equilibrium is dependent upon the way in which these adjustments are made.

We can leave out the extremely simple, primitive societies, such as those of the Australian Aborigines or Eskimo, which numerically speaking are of little importance, and concentrate our attention upon these groups of people whose principal technological pursuits are agriculture and manufacturing.

Aside from these primitives, then, the pre-war world could be roughly divided between communities which we can label by the term peasant, and those which participated fully in the advanced technology of the late nineteenth and early twentieth centuries. A good example of such a peasant culture is to be found among the farmers and fishermen of Western Ireland. Here the most important institution is the family, and the agricultural techniques by which people make their livings are all carried on within the membership of this limited circle. This agricultural system, based upon the family, was tributary to the urban system of the British Empire, since the grain and beef cattle which the Irish peasants produced as their cash crops flowed mostly to the markets of industrial England.

This Irish peasant culture, with its emphasis on the practice of agricultural techniques within the family, has changed little since pre-Christian times. The Kings of Tara, the Anglo-Norman overlords, the British territorial governors, and the Irish Free State government itself, mark successive changes in the political organization of the country, and the language of the people has even changed, without this family system being visibly altered. The reason for this conservatism has been that whatever the shifts of authority at the top of the political organization, whatever the changes in the lives of the rulers, the peasants themselves have continued to till their fields with the same kinds of tools and in the same ways and have thus undergone no visible change in basic technology. Since the relations of people depend on their roles in practicing techniques, the typical Irish peasant system has survived unaltered.

What is true of the Western Irish is true in general of peasant communities everywhere; in Russia the liberation of the serfs and the assassination of the Czar made little difference in human relations in the countryside, because the farmers were still using the same plows and the same rakes and fattening their pigs in the same way. Changes in the structure of Russian peasant society did not come with communism, but with the introduction of the tractor, just as what little change has taken place in modern Irish peasant communities in recent times is associated with the electric butter churn and other such devices.

To these peasant communities may be contrasted the urban civilization of the period in question. Each European country and many countries in other continents, had a number of cities in which people lived with enormously greater specialization and division of labor, and in which they practiced much more complex techniques than their country brethren. In urban centers people worked in factories and other large enterprises and exchanged their manufactured products for the foodstuffs and other raw materials of the countryside.

Nevertheless the relationships between urban and rural communities were limited to a few channels. The peasants bought their goods at the cross-roads store or from pedlars, but they seldom saw or talked with the people who made these objects; they remained in their rural environment and maintained their rural system of relationships in almost complete isolation. This is exactly the same situation which obtained between the nations which were largely urban, such as Great Britain and the Netherlands, and the colonial regions from which they drew their raw materials, such as the Malay Peninsula and the Dutch East Indies. The lives of the natives in these latter regions were relatively unaffected by their relations with the industrial nations; although they bought ready-made cloth for their clothing and rode bicycles, the basic techniques by which they raised their food and got along with their fellow men remained the same.

The reason why urban and peasant communities throughout the world remained relatively isolated during this period, can be found in the field of transportation. England could ship goods around the world in her merchant steamers, but they put into relatively few ports, and the distribution system on land was, except for the railroads, little better than that which existed in Roman times. The railroads themselves were costly to build and operate and could reach directly only a small proportion of the peasant and colonial populations.

Another branch of technology which was partly responsible for this situation is the field of communication. Without telephone or radio, relying entirely upon the rails and the telegraph, events could occur weeks before administrators in the capitals of world empire know about them, and what is more important, peasant populations could remain largely isolated from any administrative action.

As I pointed out in the case of Ireland, the peasant societies throughout the world achieved a state of equilibrium which remained relatively constant over a long period of time. Within the cities, as a function of changes in technology, there was a continual struggle for dominance among the various economic institutions, as each group tried to achieve an equilibrium for its members in the face of competing institutions. This attempt of technological systems to stabilize their relations with customers and sources of supply was carried over into a contest for control of the political system. Yet whichever group temporarily seized control, the life of the peasants went on with little change.

The very stability of these peasant systems and their isolation from the urban centers and administrative officers of the government made the occasional efforts of the latter to introduce changes of little avail. In fact, changes in the relations of peasants and overlords brought about automatic reactions within the peasant community, and thence reactions in turn produced a restoration of equilibrium. Thus when the overlord overtaxed the peasants, the latter became angry and banded together to resist the tax gatherers. The overlord could destroy the community but he could not change its rate of production or its level of equilibrium.

Modern Technology and the Equilibrium of Institutions:

The technology of the present period is rapidly destroying the contrast between rural and urban systems of relations, and that which has existed between imperialist nations and their colonial dependents. The reason for this is not hard to discover. In this country, which pioneered in the modern technology, country people and city people use the same technical devices for many of their operations; they both use electric washing machines, electric flat-irons, etc. They both ride in automobiles, and furthermore they can see the same moving pictures, listen to the same radio programs, and read the same magazines. With improved transportation people who work in the city can now live in the country, and people who work in the country can make frequent trips to the city. Many factories are now built in the country, and draw on rural populations for their labor.

Thus the influence of present-day technology is to bring country and city people into a single major system of relations which must achieve an equilibrium. We have no longer a peasant backlog, maintaining an even subsistence level in bad times and good, always able to eat but little more; today the farmer of the dust bowl is just as subject to profound fluctuations as the factory worker or the shipper. All of us in this country are part of a technological system based upon mass production.

In outlining the general framework for a world equilibrium, therefore, we must reckon with the fact that the changing nature of our technological system and the changes in human relations which it is bringing about are proceeding at differential rates in different countries. Attempts to organize a world system must take into consideration the fact that the necessary changes in human relations can be introduced only through the sphere of technology, and that these changes will of necessity be incorporated within the existing organizations in the different regions of the world. In so doing, however, the equilibrium will be disturbed, and if the change required is too great, a period of instability will result before a new equilibrium will appear. In order that this can be done most effectively, the changes must be made within the framework of existing regional systems. These must be granted local initiative and local autonomy, necessary for the successful operation of the larger organization by which the world technology can be stabilized.

Conclusion:

The technological changes by which man can be emancipated from too great a dependence upon nature and which will necessarily occur unless the world goes completely to wrack and ruin can cause at the time of their introduction relatively great or little harm. If they are put into operation without regard for the necessities of the systems already operating, contrary to the organization of the institutions which have already been worked out among the people concerned, then serious compensatory reactions will take place. If however an attempt is made to determine what the ordered interactions of the individuals actually are, the techniques can be introduced in such a way that the system is only momentarily disturbed, and can easily achieve a new state of equilibrium. If this is done, and to do so requires careful planning on the local level, we can look forward to the time when a world equilibrium will have become as habitual and as stable as the peasant communities of the past. Unlike these, however, they will provide a free system within which every individual can achieve an equilibrium and an effective adjustment to his world.

VI

HOW A WORLD EQUILIBRIUM CAN BE ORGANIZED AND ADMINISTERED

BY ELIOT D. CHAPPLE

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Introduction:

How can a world equilibrium be organized and administered? Any answer we choose to give to such a question can by necessity be only a partial one. Yet answer it we must if we are to survive, and our hopes of success will be immeasurably strengthened if we base our plans on the principles of human relations.

We have to begin with human beings, and with human beings who have already been conditioned to habitual routines of interaction. You have heard something of the constraints which these routines will impose upon any world system, and of the modifications and limitations upon our relations to others which we can expect from our present-day technology. Any plan for the organization of a world equilibrium must be based upon these operating realities.

Equally important in planning an organization, however, are the steps by which one's plans are put into effect, for these steps determine the form of the plan which results. Unless all the combatants disintegrate through exhaustion, the end of the war will be a military victory, followed by military occupation of the conquered countries. An organizational plan must, therefore, take into consideration the basic fact that a military occupation with military governors, martial law, and emergency measures must be transformed into an effective political system. This transformation must be carefully planned—the automatic tendencies of systems of human relations to return to a state of equilibrium must be guided within calculated channels. Otherwise, armies of occupation will tend to become permanent and will then be rationalized as a preparatory and educational interlude for a political adulthood which will never come. In the frantic haste of victory, the carpetbagger, whether the simple exploiter of our Civil War days or the more sophisticated Commission used after World War I, often seems to be the only means by which political order can be restored. As history has shown, such reconstruction methods can never bring about a restoration of local autonomy within the framework of a centralized control which will achieve equilibrium. Carpetbaggers of every form and carpetbagging policies towards the vanquished act as disturbing forces on the system, bringing about violent compensatory reactions on the part of the governed.

We cannot hope, therefore, to implement the Atlantic Charter and bring about a world equilibrium, unless these facts are realized. We must learn the bitter lesson, that we have to plan for human beings, and not for "economic men" or "political animals" or "men of good will." We have to plan, in other words, according to the ways in which people actually do behave, and not as we think they ought to behave. And our plans must contain the steps by which they are to be put into operation, steps which must be taken at the moment of military victory, and not delayed for some more propitious future which will never come.

The Relative Efficiency of Totalitarian and Democratic Systems:

Changes in the interaction rates of individuals are the disturbing forces in systems of human relations. When such changes occur, the equilibrium is upset, and the changes in the autonomic nervous system which result include compensatory changes in the interaction rates. In our ordinary experience, we recognize emotion by such changes, and we recognize too the necessity for the individual to blow off steam, to complain about the injustice done him, and to seek redress and thus, in more precise terms, to reestablish his state of equilibrium.

We have already discussed how the technical activities of every day life provide the context within which interaction takes place, and in which individuals adjust to others, or become seriously maladjusted. The organizational structure of every institution is built up on routine events in which one person acts and a group responds, and through which the technical activities can be performed at given frequencies and in habitual ways. When disturbances occur in the adjustments of individuals, compensatory reactions take place within their habitual relations to others. If these reactions alleviate the disturbance, equilibrium is restored. The efficient organization or system is that in which these reactions produce adjustments within the system rapidly and along well-defined channels.

In designing the plans by which effective organizations are set up, planning experts have already worked out many procedures which, if properly applied, can help the officers of administration to maintain a stable state within their organization, and to eliminate disturbances rapidly. In general, however the administrators use even these procedures to a limited extent only, in fact they usually apply them only to the upper brackets of the administrative hierarchy, and rarely consider the needs of those on the lower rungs. Thus they fail to take into consideration the essential unity of the system and its need to be treated as a whole.

The result is that most compensatory reactions run down the line of authority, and each administrator restores his own equilibrium, when disturbed by a higher-up, by acting upon his subordinates. At the bottom level, there is no ordered channel; the governed have only each other as outlets. In such an organizational system, which we have recently come to call totalitarian, there is no provision for modification of administrative action except by direct appeal up the line, and such an action brings about a compensatory reaction in the opposite direction. Where disturbances occur with any frequency, the flow of actions down the line requires the individuals at the bottom to be highly conditioned so as to respond automatically to the actions of the hierarchy. Each such individual can find compensatory outlets only in persons upon whom he is permitted or encouraged to act—his wife and his children, members of outcast groups, and members of other nations. A totalitarian system, therefore, prevents any modification of the structure from below, in response to changes in environmental and technological conditions. Yet it is on the bottom level that such changes are continually occurring. If the disturbances passing down the line are too frequent and their intensity becomes too great, the necessary result is conflict; where possible, rebellion, where not, non-cooperation, restriction of output, sabotage, and an increasing incidence of mental disorders.

Even though systems of this kind have operated for brief periods in the past in different countries, they are necessarily unstable, and in times of technological crises, subject to automatic and violent compensatory reactions. Under present conditions, it is highly doubtful that such systems can be as effective as was formerly possible. In peasant communities, the administrative hierarchy operated at a much lower frequency due to the low interactional requirements of the agricultural methods then in use. It was therefore possible for such a group to maintain its equilibrium even under a totalitarian regime by virtue of becoming a self-contained, highly isolated system with its relations to the outside world cut to a minimum.

Our modern mass-production technology depends not only upon the complex interrelations of countless individuals within the manufacturing institutions; it also depends upon mass-consumption. The administrative hierarchies necessary to make such a system work operate at a high frequency; an assembly line cannot be run by absentee foremen. The complex adjustments of individuals within such a system which must occur if it is to attain a state of equilibrium cannot take place if the individuals are emotionally disturbed—a necessary result of totalitarian conditions in times of peace. When war is over, and a world-hegemony has been reached, aggression on individuals external to the system no longer provides any kind of outlet. Unless actual outlets within the system are provided, no equilibrium is in fact possible.

As an alternative to the so-called totalitarian system, there has been devised the democratic or representative system, in which the people at the bottom of the administrative hierarchy are able to act upon the administrators. As everyone knows, the representative system is one in which I, the governed person, the man in the street, am able to compensate for a disturbance to my equilibrium by acting upon my representative, whom I choose, who in turn is able to act upon the administrator, in order to bring about changes in *his* behavior which will restore my equilibrium. It is a circular system in which the compensatory mechanisms are part of the organizational structure.

The democratic system is merely a representative system in which all of the administered who are adults are members of the class of those who are acted upon, and who in turn act upon their chosen representatives. The degree to which this system is effective in maintaining a system in equilibrium is a quantitative problem; whether in fact a system can be called democratic is again a question of quantity. In many countries it became, the fashion, at one time or another, to set up such a representative system, and the unwary who looked at the form and not at the working system of human relations spoke of such countries as democratic. The facts of the case were that they were merely disguised totalitarian systems, set up to make the people think that they had a voice in the government, and thus to lull them into a state of equilibrium. Since the representatives chosen by the people had no power, and the actions of the people upon these men produced no results, this ruse served only temporarily to alleviate the disturbance of the individual citizens. The fact that the representatives could bring no change in the administration meant that the circular system was not in operation, hence the governed obtained no modification of the administrative policy, and the basic disturbances inherent to such a system soon returned. In this country, a similar situation existed in the so-called company unions or employee representation plans formerly the vogue in industry; when, as was true in all except rare cases, the employees found that they had no opportunity of acting on any matters which were of real importance to them, they soon lost interest and sought compensatory outlets elsewhere.

If we are to organize a world equilibrium, we will tend towards one or the other of these two solutions of the problem. We may obtain the totalitarian solution in fact, while having the democratic solution in theory. In our opinion, the most efficient system of organization in terms of the realities of human relations, is the democratic one. It provides habitual channels within which compensatory reactions may operate to restore the equilibrium of the system. It enables one to introduce technological changes without running too much risk of causing severe disturbances of which the administrators became aware too late. It is the only method by which large scale organizations can be run efficiently. And it provides for a retention of local autonomy and local initiative within a world-wide order. The criticisms so frequently made of the inefficiency of democratic systems as compared to the totalitarian are due not to the fact of having too much democracy but of having too little. Inefficient organization is the result either of the failure to use present-day knowledge of organizational principles in setting up the organization, or of the existence within the government of a totalitarian sub-system which is successfully able to short-circuit all attempts to bring about changes in its administrative procedures. A brief examination of actual cases drawn from history will indicate to anyone that such inefficiency, with rare and temporary exceptions, is most characteristic of totalitarian regimes.

The Organization of a World Equilibrium:

If the democratic system provides the most efficient way we know of organizing a world equilibrium, the problem is, how can such a system actually be put into operation on a world-wide basis? The previous speakers have sketched for you something of the materials with which we have to work; it is my task to outline the general framework of a system of organization in which major sources of disturbance will be eliminated.

You have already heard how important a part technological routines play in determining the interaction of individuals. The greater part of every individual's day is spent in technical activities, and the complex interdependence of individuals produced by our present technology has brought about the formation of regional systems, throughout the world, each of which can attain a stable state of equilibrium. For this reason, in outlining the basis for organization of a United States of the World, each state which forms an administrative unit must not be an ethnic or linguistic group, or even a nationality; it must be a natural geographic-technological region, within which trade and the exploitation of natural resources occurs within the bounds set by natural barriers, climate, and the common highways of travel, regardless of race, language, or ethnic identity. Examples of such areas are the Danube Valley, the Mediterranean, the coasts of the Baltic and the North Seas, and so on. I shall not attempt to list all these unit regions or to set their boundaries. The exact limits for each area can only be fixed by determining whether or not the frequencies of interaction occurring within the technological institutions of a given area possess the properties of a system in equilibrium.

A word perhaps ought to be said to explain why we regard nationality, ethnicity, language, and also religion as unimportant in the formation of these natural geographic-technological regions. The organizing principle which we have followed is to select those conditioned routines which bring about the greatest amount of interaction with the stablest frequency, and to build upon them a homogeneous political unit. Trade and manufacturing bring people into habitual association whatever their race or creed. Ethnic or linguistic divisions which were so much in the consciousness of statesmen after World War I are symbolic in character; they refer to habitual ways of interacting which had, at some time in the past, a technological and environmental basis. The growing pains of the modern world system, seen in the present war, are largely the result of the necessities of the existing governments to achieve equilibrium for political institutions built upon the habitual routines of nineteenth century technology. Each change resulting from twentieth century technology, brought about compensatory reactions within the political systems, and these in turn brought about greater dislocations in the habitual routines imposed by environment and technology on the people who were at the same time subject to the rule of these outmoded political institutions. Jugoslavia, for example, was united after the last peace on the basis of language, and the struggles between the Croats and the Serbs, which have gone on ever since, reflect the essential geographical and technological disunity of this artificially created kingdom.

Where stable technological systems exist, however, people of diverse languages, and belonging to different ethnic groups, have been able to live and work together harmoniously. The Island of Great Britain, Switzerland, are but two of many examples where this has occurred. And in all these cases, when the interactions change, the symbols change with them. Thus Romansch, Italian, French, and German become Swiss. The equilibrium within these countries is not based upon the sharing in common of certain symbols, but upon the stable adjustments of the individuals concerned. Stable political institutions can only be based upon the framework of a stable technological system, upon the necessities by which people are brought face to face in their daily life.

Once regional states have been delimited, the political system for a United States of the World can be set up. The machinery in question must involve a democratic and representative system both for the regional states and for the Federal System with the emphasis within the regions on local autonomy and local initiative. The concern of the government of the United States of the World would be upon the administration of those aspects of human relations which involve the interrelations of the regional states. Its function, therefore, would be to maintain the world equilibrium by controlling and supervising the systems of communication and transportation, the allocation of raw materials and the conduct of trade and exchange between the several regions.

Basic to such a system would be the possession of a world police force, including an army, a navy, and an air force, with no rivals permitted. Of necessity, then the tools of modern warfare—planes, tanks, etc.—are reserved to the Federal system, and the regional states would be permitted only militias to keep the peace. Unless this provision is incorporated within the organizational framework, a United States of the World cannot operate. Every institution, to be effective, has to be able to enforce its decisions, to compel those who will not respond to its authority to learn to do so. Within a democratic system, the use of such power is subject to the control of the governed; it can be exercised without bringing about fundamental maladjustments.

We cannot give you a detailed blueprint of the workings of such a system. It would take time, money and the collaboration of a technical staff to produce such a scheme. We can, however, emphasize several principles which are of fundamental importance in its successful operation. The first of these is that every regional state, whether it be composed of victors or vanquished, whites, yellows, browns or blacks, must be a member of the world system on an equal basis. The administrative hierarchy of the United States of the world would then be made up of individuals from all the regional states, and The Federal Civil Service would operate much like the old Chinese mandarin system, open to all and based upon competitive examinations. The exclusion of any group for reasons of expediency or revenge or to maintain a pre-war system of control will only bring about new sources of disequilibrium. People learn only by doing, and democratic systems can be made to work only if the individuals concerned are given the responsibility. Many peoples who have been excluded from large political systems on grounds of political immaturity, as for example the Hindus, have in fact practiced such governmental methods in their local groups. Once people have been put into a position of inferiority within an organizational framework, it is to the interest of even the well-meaning to keep them there, since, if any change is made, the equilibrium of the superior groups will be disturbed. Now, however, the disturbance is so great and so general that the time has come to set such people free.

Even Germans and Japanese must be included in our policy, however painful and bitter our feelings towards them. Their totalitarian institutional systems, operating under the restrictions imposed upon them drove them automatically on their present course. It is of fundamental importance that, this time, they shall not again be provided with the means and the incentive to undergo such violent compensatory reactions, but that on the contrary, positive action shall be taken so that with them as with others a democratic system can operate effectively within a regional framework.

The Administration of a World Equilibrium:

As I pointed out at the beginning of this talk, the careful elaboration of an organizational framework within which a world system can operate is an idle effort unless each step by which it is to be put in operation is planned with equal care. In dealing with human beings, each of whom has specific physiological properties, we must continually keep in mind that they behave in accordance with these properties. Once they are conditioned to a particular way of behaving, in terms of which they achieve a state of equilibrium, they tend to remain in that state, and to return to it after minor disturbances. For this reason a basic principle of administration is that the means determine the end; once you condition individuals to a particular way of doing things, it is difficult to change the habitual systems of relations in which they interact.

Once the war is over and victory has been won, those who are responsible for setting up a new world order which they hope to make stable will be confronted with their most dangerous hour of decision. Each step that they take at the time—when the several countries of the world are in upheaval, when the victors and vanquished alike are trying under the stress of old patterns to return to some kind of a balance—will determine whether or not the next step will be possible. Temporary measures which are put into operation because no decision has been made as to what permanent steps are needed will themselves become permanent measures, and will shape the organizational structure. It is consequently necessary, in setting up a plan for a regional system of federated states, to see what conditions need to be met at the outset.

At the end of the war, the victors will be faced immediately with the problem of getting the technological systems back to a working peace-time basis. This means that not merely will it be the responsibility of the victors to disband the armies and to feed the starving populations, but to see to it that manufacturing and trade shall return to some kind of stability. We are all of us conscious of the problem involved in our own country, and it has been the concern of private agencies and of the Federal government to set up plans by which full employment can be maintained and the productive operation of our industrial system transformed into peacetime products. But this problem must be faced in every region of the globe, and the successful implementation of a technology capable of attaining equilibrium cannot be worked out after the armistice is signed; it must be prepared beforehand.

If such planning is done in detail before the war is over, it will then be possible to utilize the necessities of feeding the populations of the world, and of repairing their economic systems, as ways of conditioning the individuals in these populations to the new political system. If the framework is drawn up in advance and ready to put into operation, those who wish to introduce this system can use the administrative necessities of the post-war period for this purpose. Representative systems can be set up in the several regions to aid the administrators in feeding the populations, and in working out and directing the technological changes needed to provide reemployment for the armies. In this way there need be no period of temporizing in which the old habits and systems can reassert themselves; compensatory reactions can be directed within new channels and not left to find their way back into the old.

Such plans cannot be directed and administered unless continuous control is maintained over the developing systems of human relations. Systems of human relations, like all other systems, vary within fixed limits when they reach equilibrium. It must be part of the routine activities of the administration to take periodic samples within the different regions, in order to determine whether or not changes are occurring outside the limits of tolerance of the system in question and to take the necessary administrative action. By the use of such control methods, it will be possible to estimate the effect of a new technique upon the equilibrium, and to see to it that each increase in technological efficiency is fitted to the existing organization so that it produces an increase in the adjustment of human beings.

Such a democratic system, however, capable of attaining a state of equilibrium on a worldwide scale, can never operate unless we plan what we are going to do, long before we are called upon to do it. The conversion of a single nation to readiness for war requires years of careful planning before an M-day is feasible. The far more complex organizational framework for a United States of the World cannot be left to the chance inspiration of the day after peace has been won. We must have in our hands a careful outline of the precise steps to be taken and the order in which they are to be timed, as well as an organizational blueprint for the system as it is intended to operate.

If we are to succeed, time is of the essence. The longer we wait after the final victory, the more time is given for the various countries to return to a status quo ante bellum, and the harder it will become to introduce new systems of relations to which people must become conditioned. Our plans for V-day must be fully worked out, ready to put into operation if and when the event occurs. Lack of preparation for peace can be even more fatal than lack of preparation for war, for unless we prepare for peace, we can never hope to see an end to war.

VII

INTERNATIONAL UTOPIAS

By Zechariah Chafee Jr.

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> "Let us conceive of the whole group of civilized nations as being, for intellectual and spiritual purposes, one great confederation, bound to a joint action and working toward a common result; a confederation whose members have a due knowledge both of the past, out of which they all proceed, and of one another. This was the ideal of Goethe, and it is an ideal which will impose itself upon the thoughts of our modern societies more and more."

In this intellectual and spiritual confederation envisaged by Matthew Arnold, we scholars brought to maturity whatever within us is good for others. The Tercentenary of 1936 honored it as well as Harvard. That was its last blossoming. Already the Nazis in Germany and Franco in Spain had begun the long sequence of tragedies which, for the second time in our lives, has torn asunder the Western world of art and science and ideas. For politicians and soldiers let it be a war between groups of nations. For us it is a civil war within the single community of thought.

Arnold might assume in 1879 that this intellectual and spiritual confederation could continue in a Europe which was for other purposes divided into irregular compartments, that its unity would not be severed by the barriers of tariff walls and frontier fortresses. The two civil wars, thirty-five and sixty years later, have shown us the falsity of his assumption. National boundaries can impede the free flow of thought more than they do the less sensitive currents of trade. The confederation of the spirit envisaged at Weimar is superseded by the New Order conceived in Berchtesgaden.

And yet the ideal of Goethe and Arnold is one of the chief reasons for my belief that the International Utopias of which I shall speak are more than the baseless fabric of a vision. Europe was one in the ways that they accounted most important. That makes it easier for it to become one again in a greater number of ways. This confederation of the mind and spirit was real and had been real for centuries. There is something there capable of taking on new functions and influencing still more human activities.

A second reason for confidence is economic. I need not indulge in commonplaces about the annihilation of space, but merely illustrate what I mean from the war itself. The mobility of the very tools of destruction—airplanes, troop-trains, and tanks passing rapidly from Narvik to Crete—shows the growing meaninglessness of the old national boundaries. So does the coordination of factories creating those tools of destruction. However vile the present purposes, Europe is unified industrially as never before. May it not be possible to change the purposes and yet preserve the unity?

As a third witness let me summon Hitler himself. His New Order is a negation of nationalism and racial isolation. It is federation—of a very bad kind, surely, but yet it is federation, which Europe never had before. Countries formerly separated are now associated as master and slaves—they may later be associated as comrades in a common enterprise. A conqueror sometimes benefits his foes more than himself. Napoleon erased the outworn boundaries of many petty German states, but the resulting unified Germany passed to the very dynasty he fought. So Hitler may be wiping out wider boundaries so that soon the agents of a democracy may govern as uninterruptedly as his minions do now.

The instability which succeeded the Fall of the Roman Empire has persisted until the present day. Rival nations sliding about over each other have produced periodic earthquakes like sliding strata of rock. This war, in its early stages at least, is only the latest of a series of often senseless struggles, wars of this or that succession, whose repercussions used to loose the Indians on our forefathers and now have turned the Japanese upon us. To an American vexed by these constant quarrels, they seem likely to continue so long as an area smaller than our own is split among over a dozen independent political units each pulling in a different direction against the others and against the growing strength of the uniform techniques of industry which ignore national boundaries. In a sense, Europe has always struggled to reinstate the *pax Romana*, and now may be the best chance it has ever had to do so, albeit in a nobler form than either Trajan or Hitler conceived.

In short, with all our misfortunes, a central government for Europe—or even for the world—becomes more practicable than it was in 1919. We do not know yet what spirit will imbue that government. Oddly enough, its spirit seems likely to emanate from Germany whichever way you look at it. On the other hand, the New Order of Hitler, on the other, the European confederation dreamed of by Goethe and Immanuel Kant. Or shall there be a third course—all the old independent states once more?

May I venture an analogy from a remote part of the world? During the centuries when Greece was falling apart and Rome was expanding, China was divided like modern Europe into many warring states. They fought with traditional etiquette, changed boundaries kaleidoscopically, yet still remained numerous and bellicose. Meanwhile, the teachings of Buddha and Confucius spread regardless of boundaries. Meanwhile, the irrigation systems so necessary for Chinese intensive agriculture went on expanding. The interdependence of these canals called for a unified control of all the water in China. Nevertheless, political divisions threatened to wreck what should culturally and economically have been a single community. About the time of the first war between the Romans and the Carthaginians, a people called the Ch'in started conquering the rest of China. They did not fight like gentlemen, as other Chinese did. They beheaded their defeated foes. In 221 B.C., just before Hannibal crossed the Alps, they overcame their last antagonists, the Ch'u. At last there was one control of the water system. Bad as the Ch'in were, they had done the job. And just because they were bad, they were replaced in fifteen years by the Han dynasty, the first great rulers of a unified China. Ever since Chinese historians have hated the Ch'in.[2] It may be possible that the Nazis have with even greater cruelty accomplished the task of unifying Europe so that more enlightened successors may soon do good that was never possible before.

Along with these three factors working for unification, we have an entirely different reason which impels men powerfully to try to bring about some sort of unification. I refer, of course, to the inescapable evidence that the alternative is recurring warfare. We know well that science has made war vastly more costly and more destructive, and will accelerate this tendency; that it is increasingly unlikely for a war to be localized between two countries—once started, it spreads rapidly over the world. We know that the intervals between wars can be very short unless we do something to make peace effective. It is just as well, perhaps, that the Second World War came so soon after the First, so that we cannot ignore this lesson. We know that hereafter, unless a better order be established, even an interval of peace will be almost as bad as war, for hereafter nobody will dare to refrain from preparing, preparing, preparing, at enormous cost. You can have strong defense, or you can have civilization, but you cannot have both. Even peace will be a total organization for war, crushing out education, recreation, books, family life. This road leads straight to mass suicide—a feverish peace followed by what Kant described as "A war of extermination, where the process of annihilation would strike both parties at once . . . would bring about perpetual peace in the great graveyard of the human race."

So there is, more than ever before, eagerness to establish something new which will prevent this ruin of our race. And the opportunity will come after victory. What shall we do with it? What sort of new world is desired? Several sorts, in fact. Many books and magazine articles have already broached different schemes, although the subject of post-war organization has not yet received much attention in daily newspapers. There is some danger that people will get so bewildered by all the overlapping and conflicting proposals that they will throw up their hands in despair and stop thinking about the whole matter. That would be a great misfortune, for an enlightened public opinion on the right use of the victory for which we strive will do much to save us from throwing that victory away.

On the other hand, some persons incline to seize on a single scheme and fervently hail it as a cure-all with no thought of adverse criticisms and alternative possibilities. Fanatical devotion to one plan at all costs wearies listeners and alienates supporters of other plans. Competing zealots may raise such a clamor that they will silence each other and disgust everybody else. So no features of any international scheme will win general acceptance, and we shall be back to some form of the balance of power.

Consequently, it is wise for Americans to consider more than one scheme, yet not too many schemes. There are four main types of International Utopias that have considerable influence. Each of them stands out pretty distinctly despite many divergences among its supporters about details. Consequently, it will simplify the problems of post-war organizations to distinguish these four schemes from one another, and illustrate each of the four by means of a brief description of a significant book.

At the outset, I want to make it plain that all four plans are like the famous recipe for hare soup, which began: "First catch your hare." Every International Utopia presupposes the downfall of Hitler and the other Axis rulers.

I

The first plan is to improve and strengthen the League of Nations. In twenty years it showed several kinds of defects. Its most outstanding failure was the breakdown of economic sanctions against Italy during the invasion of Ethiopia in 1935. Hence there has arisen a strong movement in favor of stronger sanctions and more effective methods for bringing sanctions into operation. It is to be made really a League to Enforce Peace. An able and very thorough presentation of methods for this purpose is made by an Englishman, Lord Davies, in a book of seven hundred pages entitled "The Problem of the Twentieth Century." Lord Davies is an elderly man. He became the active head of The New Commonwealth, an international society devoted to the establishment of an international police and other devices for strengthening the League. It published a number of research monographs. His book suffers from being older than the other books I shall discuss. The first edition was published in 1930 and a revised edition in 1934. Hence it is not in form a post-war plan, but its reasoning is capable of adaptation to the situation which confronts us.

After a full and informative analysis of older proposals for international unification, like those of the Abbé Saint-Pierre and Kant, he takes up more recent expressions of the idea of an international police force. I was surprised to learn that in 1910 both Houses of Congress passed a resolution asking President Taft to appoint a commission of five to consider among other aspects of disarmament "the expediency of . . . constituting the combined navies of the world an international police force for the preservation of universal peace."[3] Taft took some steps but no cooperation then seemed feasible. Although Wilson at Paris dropped force out of the League, this was inconsistent with his utterances of January 22, 1917, in his speech on Peace without Victory:

> "Mere agreements will not make peace secure. It will be absolutely necessary that a force be created as a guarantor of the permanency of the settlement so much greater than the force of any nation now engaged or any alliance hitherto formed or projected that no nation, no probable combination of nations could face or withstand it. If the peace presently to be made is to endure, it must be a peace made secure by the organized major force of mankind."

Lord Davies would carry out this proposal of Wilson and expand the idea in the congressional resolution so as to include an army and an air force as well as a navy.

Under his plan there would be three types of police: (1) the ordinary police we have now to maintain local order; (2) a national body of police in each country to maintain national order and supplement the local police; (3) an international police force to maintain international order. Their two principal functions would be to repel aggression and to enforce the decisions of the World Court and arbitration tribunals. Unlike the Holy Alliance, the League is not to intervene in the domestic affairs of either members or non-members. A fortiori another state is to be kept from so interfering.

One of Davies's most interesting points is that the progress of invention has now made possible a differentiation of weapons, so that the international police can be armed much more powerfully than will be allowed for any national body. Some sort of differentiation has long been common inside a country. The local police carry clubs or at most revolvers, while the national guard and the army carry rifles. According to the plan of Lord Davies, each national army would be limited to weapons existing before 1914, whereas the monopoly of the newer and more powerful weapons would be possessed by the international police. These would include submarines, airplanes, poison gas, tanks, the new heavy artillery and bombs. All these weapons would be forbidden to the national armies. Such a differentiation was proposed by France at a disarmament conference in 1932. The Washington conference of 1921 also furnishes a precedent, for differentiation was there used in a negative fashion to forbid certain powerful weapons and reduce others while some weapons were left unrestricted. If the proposal of Lord Davies could be effectively carried out, it would have two great merits. In the first place, it might very well make the international force more powerful than any combination of member states with their limited equipment. A combination of outside states would be met by an even stronger force as I shall show later. On the other hand, his plan would not impair the ability of each state to maintain law and order in its own territory. The burden of the international force would be met by contributions from member states in personnel, arms, and money. States which failed to contribute would be unable to participate in the management of the League, whereas in the past no such penalty was imposed and Peru even obtained a seat on the council after it had been years behind on its annual assessment. A delinquent state would also be denied the use of the international force for the protection of its own frontiers. Another new device would be an international general staff which would render the international police effective and mobile. Thus sanctions would be organized before the crime was committed, whereas the actual League has been greatly handicapped because the economic sanctions which it could use had to be worked out after the violation of law. For instance it was several months after Italy invaded Ethiopia before the League could decide what to do. The international force would embrace all the instruments of coercion. If it consisted of a navy alone, as Congress proposed in 1910, it could not have prevented the German army from overrunning Europe in 1914. Hence an army and air force must be included. Perhaps the development of aviation will eventually make an international air force sufficient.

How shall the international police force be organized? Davies describes three alternative schemes:

(1) It will consist entirely of quotas furnished by the member states, each of which will control its own quota and pay its cost in time of peace. However, a general staff at international headquarters will organize these scattered quotas, and on mobilization it will take them over under international command. This was the French scheme at the Versailles Peace Conference. One advantage is that it would cause a minimum amount of interference with existing national establishments and yet bring about considerable disarmament in each country. However, there are several disadvantages. There is no adequate guarantee that a nation would meet its obligations when the crisis arose, and thus the League might lack the support it had counted on. This uncertainty would discourage apprehensive nations from diminishing their national forces. Also, it would fail to eliminate competition between the war offices and admiralties of different countries. A national staff would resent the intrusion of the international staff. When each nation retained financial control during peace it would be tempted to spend more in making more, to prepare peace industries for transformation into munition factories, and to invent new weapons for its own use. Secession is made easy, just as the southern state militias in 1861 became the Confederate Army. Finally, this scheme disregards the hopeful new opportunity for differentiation of weapons.

(2) At the other extreme is a complete self-contained international force, with the abolition of all national forces except as they are necessary to maintain internal order. This scheme would have the advantages of eliminating all competition between countries, obtaining comprehensive disarmament at once, producing increased mobility of the international force and simplifying the problem of organization. On the other hand, the disadvantages are numerous. The League would have to possess a bigger force than it would ever be likely to use. This force would be much more expensive to maintain than national quotas. Even if some of it could be kept within international territory, considerable portions would have to be garrisoned inside member states, which would cause disputes. The problem of maintaining internal order would become much more difficult. Each country would be stripped to its local police who would have no national army to fall back on. Finally, since there would be no liaison between national and international staffs, the people of each state would be wholly cut off from the international force and might cease to regard it as a genuine part of their own defense system.

(3) Therefore, Lord Davies favors a compromise scheme. He would have a composite force: both national quotas and a specialized contingent which should be enlisted, equipped, and controlled by the League. This plan was proposed by General Gerard, a far-seeing Frenchman, in 1923. Here Lord Davies's ideas of differentiation of weapons would have full scope. The separate national quotas would be armed with older weapons, and the international contingent with newer weapons. He finds many advantages in this scheme. First, the central contingent would have unmistakable superiority over the armies of member states, which would be decisive in an emergency. It could also hold off outsiders long enough to give time to assemble the national quotas, and the combined force would then be overwhelming. Second, competition in the invention and manufacture of new weapons would be abolished. Third, substantial disarmament would be produced unless a non-member state starts competing. Fourth, it would give permanence to the League, for a member would be unlikely to withdraw once it had surrendered its most potent weapons. Fifth, the sovereignty of states is preserved for they would control their quotas, and the central contingent is dependent on their contributions. Sixth, the

scheme is practicable. The technical arrangements of each country go on, of the older sort. The international police is small with specialists as aviators, tankmen, etc. Its small size simplifies the problem of international barracks and bases. It also renders the central force very mobile. Seventh, the continuance of a liaison between the national staffs and the international staff makes every nation directly interested in the efficiency of the central contingent and in fruitful cooperation with the League military authorities. Eighth, self-defense is recognized in a relative form. The frontiers will be guarded by their own national quota, then by the rapid arrival of the central contingent, and finally by the later mustering of the quotas of other members of the League. Thus the third scheme meets the objections to the first two.

The international force will owe allegiance to the League like the present Secretariat and will presumably cease to be citizens of their former states. The headquarters and bases will be independent territory of the League, like the District of Columbia and the federal forts in our country. During a twenty-five year experimental period, which Lord Davies shrewdly advises, these territories might be merely taken on lease. The bases should be chosen for their strategical position, access to the sea, and suitability for fleets of airplanes. They should not be too close to any great powers. He proposes Palestine as the District of Columbia, because it satisfies these requirements and has strong associations for citizens of so many countries. Other strategical points to be occupied include Suez, Panama, Singapore, Djibouti, Corsica, the Hawaiian Islands, Constantinople, the Aaland Islands, and Yap. It might also occupy neutralized zones like the Rhine Valley, the Dardanelles and Bosphorus, and the Great Lakes. Small states might lease part of their territories as part of their contribution, receiving full protection in return. For example, Albania, Monaco, Latvia, Honduras, Newfoundland, and Haiti. The League would have its own aircraft factories; and it would ration orders for other munitions among many states, storing them at international bases.

Although this sounds very elaborate and some details would certainly be rejected by the United States, it seems possible that the international police would become less costly as the world became increasingly habituated to peace. Lord Davies wisely observes that a good centralized police force tends to eliminate all force, including itself.

In order that the international police force may be satisfactorily organized and operated Lord Davies would remove a second usual objection to the Covenant, namely, the requirement of unanimity for most acts of the Council. He would have an executive body capable of managing the police and of enforcing sanctions and the decisions of international tribunals. The prompt action of the executive must be assured by the residence of representatives of the member-states at the capital. The actual executive must not be too large or unwieldy. Countries should be excluded which do not maintain international order or fulfill their obligations, including the payment of contributions. The apportionment of contributions would be based on wealth and other factors as well as population. This does give big states an advantage, but they already possess this now for the purpose of piling up armaments. They will be equal in the judicial sphere, the privilege of representation on the assembly and freedom to criticize. Small states as a class will be represented on the executive body. Instead of the rule of unanimity he would substitute a two-thirds vote, thinking a majority too much liable to make mistakes.

Several objections to the plan of an international police are discussed by Lord Davies himself and also in a shorter book on "Theory and Practice of International Police," by Professor Hans Wehberg, a German scholar long teaching in Geneva (1934). Here are some of them:

The force may suffer from disloyalty within, because policemen will be more devoted to their countries of origin than to the League. In reply writers point to the success of the French Foreign Legion, the Swiss Army, the composite army of the Allies in the World War, and the frequency with which men change their allegiance on migration.

Secondly it is urged that a single nation or group of nations could overcome the police either by a sudden attack or by secretly acquiring a considerable supply of the strong weapons. Lord Davies deals pretty well with the danger of sudden attacks, in view of the mobility and strategic locations of the international contingent. The quota of the attacked nation would be able to hold up the invasion for a while, so long as the invaders possess the same sort of weapons. However, this reply is greatly weakened if the invaders have secretly acquired airplanes and tanks. Lord Davies does not sufficiently show how the monopoly of these strong weapons in the central contingent is to be maintained, or how a member country is to be prevented from inventing and using new devices. This seems a particularly serious danger.

Third, one power might try to get control of the central contingent. Fourth, this might go in for politics on its own and behave like Wallenstein's army in the Thirty-Years War or the Roman army in bad periods of the Empire, ready to go anywhere under a leader who promised high pay and abundant loot. The reply of Lord Davies to these two objections is that treachery and conspiracy would be difficult in a force with three divisions for land, sea, and air, each having a separate head for a limited period of time, and all paid by the executive. He doubts if one state or one leader could influence all the heads and all the divisions. Although I am not entirely satisfied by this reply, Lord Davies goes on to give a better reason: "Every scheme has its risks. Every federation has been faced with the possibility of the disruption of its central force. Every government is liable to be deprived suddenly of its sanctions. These possibilities are inherent in any political system, national or international, but it does not follow that they will be realized. The effective safeguards are to be found in the public opinion of the countries participating in the confederation, and in the common sense of the international police."

Over and above this, the international police must not be viewed in isolation. The success of this device depends much on the general strength of the League as a guardian not merely of formal international law but even more of the idea of justice in a broad sense. The peoples must want tc cooperate in the League, not in order to keep down a certain group of states, but in order to serve the well-being of the world. In other words, security and disarmament and just international relations are three interdependent factors. Lack of any of the three interferes with the two others. It is proper to isolate each of these factors for purposes of study and detailed discussion, but in the end they must be considered together and all treated satisfactorily.

Therefore, it is important to cure not only the two defects in the Covenant already mentioned—weakness of sanctions and the unanimity rule, but also to remove other defects which have produced a strong sense of injustice. Three of these may be mentioned. First, the handling of minorities is poor, and produces a feeling of insecurity in the majority and of injustice on the other side of the boundary line. One suggestion is periodical visits by a League inspector, who would ascertain the facts, deflate peevish complaints, cut through the excuses of the majority, and often be able to effect compromises before quarrels become serious. Also a Minority Commission at the capital would receive periodic reports from governments with minorities and be able to question their officials. Next, although the mandate system is an advance on previous practice, several writers advocate that all non-self-governing territories should be administered directly by the League, which should undertake to fit them for independence and conserve their raw materials for the benefit of the natives as well as that of consumers generally and not to profit investors or governments. Finally, there must be an effective machinery for the peaceful change of treaties and boundaries which have been rendered unsuitable by new conditions. The powers of the League under Article XIX have been narrowly interpreted and never used. Some writers would transfer the power to make just changes from the Council to the World Court, but any lawyer will realize the danger of trying to combine the judicial settlement of disputes which are suitable for the application of general rules of law with the uncontrolled exercise of a vague sense of fairness. It would be much as if our Supreme Court added to its present functions the power to determine how big an income tax the rich should pay in order to provide funds for the WPA.

Even if defects in the covenant are remedied by the establishment of an international police and other devices like those described, the League is not likely to succeed unless there be also a new spirit. Of this I shall have something to say later.

II

Instead of a League, it has been widely proposed that nations should form themselves into a Union. The difference between these two types of international organization is very important. In a League the nation is the unit. Each national government selects its representatives for the central legislature and executive groups. The central government is financed by contributions from the treasuries of the member nations. In case of any violation of international agreements, coercion is exerted on the government of the nation which is committing the violation. A Union, on the other hand, makes every human being within it the unit. The citizens of the member-nations elect their representatives to the central legislature and perhaps also vote for a chief executive official. The central body imposes taxes directly on citizens. The force of the central body is exerted against the individuals who are responsible for international wrongs. The central government takes charge of matters of common importance like defense against aggression, while the national governments confine themselves to the affairs of their own respective territories. The difference between a League and a Union is, in a general way, like the difference between the Confederation of our thirteen states which fought the Revolution and the national government which was set up by our Constitution in 1789.

The leading advocate of a Union is Clarence K. Streit. His "Union Now," a book of three hundred pages, has gone through many editions, and societies with local offices in numerous cities to support his plan are active both in this country and in England. The book first appeared in October, 1938, shortly after the Munich crisis. Mr. Streit then proposed that fifteen North Atlantic democracies should immediately form a Union, which would be capable of growing into universal world government as other nations qualified themselves for admission by establishing popular self-government and civil liberties. His fifteen democracies were the United States, the United Kingdom and five Dominions, Switzerland, Sweden, France, Belgium, the Netherlands, Denmark, Norway, and Finland. Unfortunately, six nations at the end of this list have since become ineligible. So, outside the United States and the British Empire, nothing is left of his nucleus of a world government except Switzerland and Sweden.

Under the Streit plan, the Union government would deal with five matters of common importance—citizenship, the maintenance and use of defense forces, customs with international free trade, money, and the postal and communications system. Other powers would be reserved to the national governments, and the Union would guarantee to each nation protection against enemies, foreign and domestic, and the maintenance of democratic self-government and those rights of man that exist in all the democracies.

In Streit's illustrative constitution the Union will have a Congress of two houses, elected by popular vote. The lower house will be roughly apportioned among the member-states according to population, while each state will have two senators except that four would come from France, Great Britain, and the United States. An Executive Board of five men will be chosen, three by popular vote, one by each house of Congress. The judicial power is vested in a High Court.

Streit argues at length that such a Union is superior to conceivable alternatives. The old balance of power can no longer keep peace, and neither can limited alliances. "We get peace by putting so much weight surely on the side of law that the strongest possible lawbreaker cannot possibly offset it and is bound to be overwhelmed." He stresses the weakness of any League of Nations. It cannot act in time, because as he thinks, a League cannot escape the unanimity rule. To get the agreement required for action not only all the delegates must be persuaded, but also the governments behind them, and in democracies this means that the legislatures must be persuaded too. By contrast, a Union can act swiftly through a majority vote of those on the spot. Consider the speed with which New Deal measures were adopted in the United States. Furthermore, a League cannot enforce law because it must operate against a state. No big state can be coerced. You cannot indict a whole nation. Even if the League succeeds, the condemned people is resentful. What makes matters worse, the nation which is the lawbreaker in one incident still sits as judge over a different lawbreaker. Thus Italy while undergoing sanctions still took part in League hearings on Germany's violations of the Locarno Treaty. There is no sheriff in a community where every man is equally sheriff. Streit raises similar objections to a permanent League police force.

Objections about the difficulties of inaugurating the Union are met by the persuasive analogy of our own situation in 1787. The makers of our Union went straight ahead, unafraid of the future.

> "Yet they lived in a time when New York was protecting its fuel interests by a tariff on Connecticut wood and its farmers by duties on New Jersey butter, when Massachusetts closed while Connecticut opened its ports to British shipping, when Boston was boycotting Rhode Island grain and Philadelphia was refusing to accept New Jersey money, when the money of Connecticut, Delaware and Virginia was sound, that of all other States was variously depreciated and that of Rhode Island and Georgia was so worthless that their governments sought to coerce the citizens into accepting it. In those days New York was massing troops on its Vermont frontier while the army of Pennsylvania was committing the atrocities of the 'Wyoming massacre' against settlers from Connecticut."

Variations of this plan for a Union have been set forth by other writers. Thus Grenville Clark, a leading New York lawyer and a Fellow of Harvard, published at the end of 1939 "A Memorandum With Regard to a New Effort to Organize Peace and Containing a Proposal for a Federation of Free Peoples." His scheme differs from Streit's in limiting the powers of the Union at the start to defense only. Also he would add to Streit's fifteen members Argentina, Colombia, and Chile. The most influential English book appears to be W. B. Curry's "The Case for Federal Union," which adheres closely to Streit's plan. This pamphlet of over two hundred pages was published in the autumn of 1939 after the outbreak of war.

Many of these proposals for international political organization remind me of some plans for an international language. An American urges that life would be much simpler if everybody spoke English, while Mussolini predicts a Europe where Latin will once more be universally used. The originator ends where he starts, in his own country. In the same way the draft constitutions of Streit and Clark, both Americans, bear a close resemblance to the Constitution of the United States. On the other hand, an Englishman, John S. Hoyland, has produced an interesting little book of one hundred pages, "The World in Union," which though falling within Streit's general scheme makes considerable use of English experience with administrative bodies of experts. For instance, he proposes a world economic council, composed of representatives of employers, employees, and citizens generally, which would be in charge of reconstruction of areas devastated by war, and readjustments due to the introduction of free trade. from which some regions now having a high tariff would suffer for a time. This council would also bring oriental countries up to the same standard of living as western countries in order to prevent the latter from being flooded with cheap labor, and would seek to eliminate poverty all over the Union.

Hoyland has given us a better book than Streit's, which I find very heavy going. Some of the divergences are due to Hoyland's strong religious feeling, which is especially prominent in the last chapters. Unlike Streit, he wants no sanctions. "The peoples must want to come into the Union." Also Hoyland would include the Axis Powers and Russia despite the undemocratic nature of their institutions. To the objection that Union is then risky he replies that it is risky anyway and even more so if sanctions are inserted and several great powers are excluded from membership. "You have to trust the future. Take one step at a time. Do the right thing now; and believe that as you do the results will be sound and attractive enough to quell the spirit of violence and separation before it comes to strength." On the other hand, he says "There is no future for national sovereignty." It will shatter civilization.

The diminution of democracies since Streit published "Union Now" after Munich has led him to write a second book "Union Now With Britain" (1941), proposing that the United States should at once federate with the British Empire.

Some kind of association of the English-speaking countries seems more probable than World Union or the other three schemes I am discussing.[4] China and Russia, for which Mr. Streit did not allow, are likely to be partners too. However desirable such cooperation of the victors, it is not an International Utopia. An association to enforce the terms of peace upon the vanquished and nurse the occupied countries back to order and prosperity may prove necessary and do its work very well, but it is only a temporary receivership although it may last for years. No four governments, however enlightened, are wise enough to run the rest of the world altruistically for decades. Sooner or later the conquered and occupied peoples will demand the return of self-government and a share in the process of world-administration. If this demand be denied indefinitely, trouble is bound to arise. Our Congress will get weary of paying a quarter of the cost of policing the world. The excluded nations will try to band together against the Big Four inside, and the so-called Union will be little more than one alliance against another. Finally, not all the internationally-minded statesmen live in the United States, the British Empire, China, and Russia. Whatever the shortcomings of the League, it revealed such statesmen in France, Germany, Scandinavia, Latin America, and elsewhere. The task of international organization will be very difficult, and it would be fatal to reject the help of the best men wherever they live.

Therefore, an association of victors should be regarded as only a transition to something wider, and the problem still remains—what shall this something else do? Even if the four principal Allied Nations now form a Union like Mr. Streit's, this cannot be forced down the throats of other countries when they do revive. When general participation becomes practicable, it will not succeed unless the scheme is reasonably satisfactory to the new members as well as the old. Everything must then be reconsidered. The result may be an expansion of the arrangement among the victors, whether Union or something looser; it may be a strengthened League of Nations; it may be one of the two schemes still to be described.

III

The difficulties of world federation have led some writers to substitute a more modest scheme for federation in Europe alone. An interesting book of this type is "The United States of Europe," by Alfred Bingham, who is an American and edits the magazine "Common Sense." His book was published in 1940 before the fall of France.

Bingham favors a Union resembling Streit's, but with smaller powers over a smaller area. He believes it best to use what we have whenever possible, rather than attempt to build a completely new and more logically perfect structure. He would omit the United States because we are less prepared to surrender our national sovereignty than are European countries; the Soviet Union, because it covers two continents and has different institutions; and the Far East, because it has its own problems. "Federations have grown up where there were some fairly obvious common interests and the possibility of a common loyalty." Europe meets these tests. The idea of European unity, though subconscious, has always existed in the European heritage. There is the common background of Greek thought, Roman Law, Christianity, the use of Latin, even the same habits and clothes. Unity was approximated by the French Revolution and Napoleon. The idea has lately been popularized by Count Coudenhove-Kalergi, Rathenau, and Briand, who was partly moved by the desire to confront American prosperity with a strong Europe. Plans for a customs union have been brought forward. European workmen have been joined together by a single song, the Internationale. Bingham stresses the long establishment of numerous international bodies for mail, telegraphs, health, the navigation of the Danube, copyright, electric power, agriculture, banking, and the regulation of maritime affairs like lighthouses and buoys. These bodies have been called bricks without mortar. They need something vital to draw them together. Also Europe has had a considerable experience in the theory and practice of federalism in Switzerland, Germany, and the British Commonwealth, besides Russia which he would exclude.

Bingham's Union is looser than Streit's. He would not speak of secession one way or the other. He would not require the internal government of member states to be uniformly democratic. India shows the possibility of diverse institutions within a federation. Instead, he would meet persecution by allowing the victims to emigrate freely and take their property with them. Then he would wait for the dictatorships to alter, believing that the federal structure of Europe as a whole will encourage local democracies. Unlike most post-war plans, this book does not emphasize disarmament. Bingham believes that armaments are a superficial symptom of deeper disorders. Peace within the United States of America, he says, is not due either to the national army or to abolition of state militias. He would like to forget the term "international police force." Coercion of a state or its inhabitants is war. The only genuine protection against civil war inside the federation is good government. Although he would meet external aggression with an international army which should have the monopoly of offensive weapons, somewhat in accordance with the plan of Lord Davies, Bingham believes that the real answer to competitive armaments is the maintenance of high standards of government which will rapidly demonstrate the advantages of European union. War will be abolished when government has replaced anarchy in areas now left to the arbitrament of force.

As to boundaries, Bingham says that ideally Europe, at least west of the Vistula, should be a single economic area with complete freedom of movement for men and materials, having merely those administrative subdivisions that prove convenient. It is not practicable to go that far now. However, one practicable and valid principle for political boundaries is to make them mean as little as possible. This is better than attempting to redraw political boundaries. "New boundaries raise as many problems as they settle. The less tinkering with boundaries the better." One way to makes boundaries mean less is to have different boundaries for different purposes as in our country, where the federal reserve districts are not coextensive with a state or with other kinds of federal regions. In the same way European political boundaries need not coincide with cultural boundaries for the language used in schools, etc., or with economic boundaries set up for labor regulations, river traffic, or the efficient industrial administration of a coal and iron area. The desire for cultural autonomy, which has been so troublesome in the past, can be better satisfied in a federation than with independent nations on a military basis. For example, Alsace might then develop in its own way without being suppressed by either France or Germany.

The central government would maintain the army (for defense and not as a police force) and a navy. It would carry on foreign relations though national diplomacy would continue. It would have power to tax individuals, protect minorities, and hold a plebiscite in any region on the question whether it should become partly or wholly autonomous.

Sub-federations would be possible, for instance in Scandinavia or the Balkans. This would be like the New England Conference of Governors. Indeed, European federation may, Bingham thinks, be preceded by several attempts at partial federation, already illustrated by the close association of England and France during the first months of the war.

Colonies outside Europe seriously complicate any plans for European federation. It is too simple to throw them all into a single melting pot. You could not include the Dominions, India, or Algeria. However, colonies are less important than the "have not" countries think. Instead of pooling or redistributing non-self-governing colonies, Bingham would give the Union considerable power over colonial administration. The greatest need is that the resources of a colony should benefit its inhabitants. He compares a colony to the zinc and lead region in the Ozarks, which enriches outside investors and leaves the natives poor and unhealthy. International agencies should be set up to regulate investments and the conservation of scarce resources; and this should be done for the benefit of the inhabitants, consumers all over the world, workers, investors, governments, and future generations. The mandate principle is sound when really applied, but he thinks the European Union would carry out this principle better than the League.

The United States of Europe would exist within the League of Nations. There might also be other international organizations like the Pan-American Union, the British Commonwealth, the Soviet Union, an association of Far Eastern nations, and perhaps one of the desert peoples of North Africa and the Near East. These regional unions in Europe and elsewhere may prove only a brief interlude before world federation.

In conclusion, Bingham warns us that perfection is not just around the corner any more than prosperity. Our own Constitution succeeded only through compromises, political deals, and the accidents of personality.

A somewhat different plan for European Federation is proposed by Arnold Brecht, a professor at the New School for Social Research, in a stimulating article in the Harvard Law Review for February, 1942.[5] Mr. Brecht, being a German, escapes from the usual analogy of our Constitution. Instead, he derives several interesting suggestions from the German Confederation of 1815–1866, which, as he observes, worked better than the League of Nations. "It soon resulted in sweeping eliminations of tariff barriers and it succeeded in preserving peace for about fifty years. Its end was not anarchy, but a more perfect union, plus an alliance." This article suggests the reflection that we need a cooperative endeavor to frame a plan for international organization. In a group of experienced men from different nations, each would be able to contribute fruitful ideas from his own governmental system. The resulting combination would be more likely to win acceptance from many countries than would a plan shaped largely by the political institutions of the United States or any other single nation.

IV

The last book to be considered at length is very hostile to the views of the other three books. It is "Federal Illusion?" by D. M. Pritt, a prominent English barrister and a Labor member of Parliament. This was published in 1940, apparently before the fall of France. It advocates a Socialist Union like that in Russia.

The chief position taken here is that war cannot be ended by proposals which leave our main economic structure untouched. The causes of war are economic, as socialists said long ago, and only socialism will insure peace. War is due to the effort to get into closed markets and obtain new fields for investment and new sources for raw materials. However, war is impossible between socialist states. They cannot quarrel over exports. There are no private interests, and the socialist system of producing what the people need and enabling them to buy it eliminates the whole element of scarcity of markets. Your country is your own market. You produce all you can consume, and consume all you produce. Nobody fights over water when there is no drought. International trade in a commodity then becomes just a question of convenience; it does not make the rich profit or the poor starve. There is no quarrel over the exploitation of colonial races, when there are no colonies, no exploitations, no private capital.

Because war is inherent in the nature of modern industrial states and the men who hold power in these, all previous schemes for peace have failed. Arbitration, formerly regarded as a panacea, does not affect the deeply-rooted conflicts of interest between rival states. The League of Nations failed because it was always designed to be an instrument for securing the protection of the imperialist and economic system of the major powers. If these interests prevented the League from fulfilling its limited functions, they would a fortiori prevent any wider federal union from operating under the present economic system. So Pritt's argument runs.

The requisites of a successful federation are then analyzed with considerable shrewdness. Not every group of states will be willing or able to federate effectively or even ineffectively. Dicey laid down two conditions for federation: (1) A body of countries like the Swiss cantons, the American colonies or the Canadian provinces so closely connected by locality, history, race, or the like, as to be capable of bearing an impress of common nationality in the eyes of their inhabitants. (2) The existence of a very peculiar state of sentiment among the inhabitants of the member countries—a desire for union and not for unity. There is no basis for federalism if there is no desire to unite. For example, the scheme in Cromwell's time for uniting England and the Netherlands was one of those dreams which may haunt the imagination of politicians but can never be transformed into facts. On the other hand, a desire for unity will lead to a single nation rather than federalism. Dicey adds that the distribution of the different powers of government between the central body and the member states, which federalism necessitates, requires courts to possess authority to act as interpreters of the Constitution. Federalism substitutes litigation for legislation. Hence it can flourish only among communities imbued with the legal spirit and a reverence for law. Furthermore, each federation has grown up under historical conditions peculiar to itself and its own reasons for existence. The United States grew out of common aims in a revolutionary war and a rising capitalist economy which demanded for its proper functioning a national market. There was no probability that competitors would amicably federate with it. Even the extension of American sway over our present area was not idyllic, for the Indians were exterminated, new territories were acquired by war with Mexico, and a great Civil War occurred.

The federal union advocated by Streit and others fails in Pritt's opinion to satisfy the requirements laid down by Dicey. The great powers have no real desire to surrender any part of their sovereignty in the political, financial or industrial field. They want to hold on to every fragment of power they possess. Even if disputes were settled by the executive or the legislature, it would be hard to get acceptance. There is even less chance that the decisions of courts would be accepted, and such acceptance is essential in federalism.

There is no force to the argument that tariffs and other barriers to commerce can be abolished by the establishment of a federal state. They are really weapons of the economic warfare between the ruling groups in a modern industrial state. The powerful interests which depend on these restrictions for their prosperity, for example, in the United States, will not consent at the behest of the federal state to lay their industry bare to foreign competition. Differences in labor costs alone show the impossibility of this. Pritt reminds us of the difficulties caused by the color bars at Versailles, although it is not quite clear just why he blames this on the rich.

The plan for the federal legislature rests, Pritt thinks, on two false assumptions: (1) That elections can be taken at their face value without investigating the conditions under which they are carried on. It is notorious that many ostensibly democratic elections are fictitious and dishonest. Wealth controls. The results would be even more warped in dictatorships and undeveloped countries. The ruling interests of different nations would merely carry their fatal rivalries into the new legislature. (2) It is assumed that all states in the federation are equal. This completely ignores the distinction between great powers, small powers, and client states under the influence of the great powers.

Then comes a sharp thrust. Streit's proposed Union is not really a world union, but limited to fifteen states. It is the preliminary syndicate and not the operating company. Many states are still left outside to fight. It excludes China, the East Indies, and Russia, which make up half the human race. Indeed, if we disregard small states and client states, the so-called world union comprises only Great Britain, the United States, and France. It is just like the proposed abortive alliance of 1918 and merely revives the Versailles grouping in place of the Four-Power Pact at Munich. The omission of Russia is extraordinary because it is the biggest example of a federated union, the most modern and the most thoroughgoing. Yet its constitution is wholly ignored as a model. It is more democratic than France where women cannot vote, or South Africa where the majority of adults cannot vote, or the United States where Negroes have been practically disqualified. It treats the Jews better than do other countries. Russia is a democracy where people manage affairs in industry as well as in strict politics. So Pritt reprints the Soviet Constitution in his book as an illustrative substitute for Streit's revamped American constitution.

Russia proves that a federation of socialist republics is easy, whereas a federation of capitalist countries would at most amount to a Holy Alliance of a few powers and their satellite states. Some republics came into the Russian federation on their own initiative, but the capitalist states within the former Russian area showed no disposition to enter and would not have been welcomed. A socialist country is unified while a capitalist country is split into hostile sections. Colonial problems are not met by Streit's union, for it omits India and puts other dependencies under control. So likewise, the United States of Europe is bound to turn into a joint plan for the plunder of the colonies. But in a socialist federation colonies become people with equal rights.

If the Union be made broad enough to include Russia and other omitted countries, states which are so different cannot achieve Dicey's requisite of a feeling in favor of uniting, either for sentiment or for industrial and commercial interests. It would be impossible to federate effectively without eliminating conflicts between wealthy groups, and only socialism permits this. Consider the difficulties of an attempt to allocate markets for cotton goods between manufacturers in Great Britain and Japan. The old conflicts of interest will remain in the member nations which are not socialistic, such as restricting production to keep up prices, oil and wheat, desire for expansion, unemployment, wealth, and poverty. Union is a smoke-screen for the reactionary war aims of British and French ruling classes.

It is true that a real federation greatly reduces the danger of war. This is not because the states are federated, but because the very connections between them which led them to federate also reduce quarrels and frictions to small proportions. Federation and friendship are not cause and effect, but effects of the same causes. The attempted federation of groups of states with no real inclination toward union contains no genuine peacemaking qualities. It will solve none of the real problems.

However, socialism removes the real causes of war. Countries which have abolished capitalism then have a strong common interest and a freedom from conflicts which facilitate union, as in Russia. The U.S.S.R., Pritt concludes, must be our model.

This completes my survey of four post-war schemes. One more book is worth mentioning, although it proposes no scheme. This is a pamphlet issued by the Carnegie Endowment for International Peace, entitled "Preliminary Report and Monographs of the Commission to Study the Organization of Peace." It appears as International Conciliation No. 369, for April, 1941. This is written by many different experts. Each gives a brief but meaty account of some difficult problem of international organization. I have found this the most helpful of all the books I have consulted.

Conclusions

A few remarks of my own may be ventured about these four schemes. I find it easiest to start with Mr. Pritt and work backwards.

The plan for a Union open only to socialist states seems to me the least promising of all the schemes. To begin with, the U.S.S.R. is the only nation now able to pass the admissions-test, so that great internal changes must take place in Great Britain, Canada, the United States, China, France, and several other countries before the new world federation can be formed. Even a European federation must be put off until the same drastic process has taken place on a smaller scale. All this offers a gloomy prospect for peace during our lives or our children's lives. The establishment of socialism in Russia was accompanied by a long civil war and followed by a good deal more bloodshed for political and economic reasons. If, as Mr. Pritt contends, there are no conflicting interests inside a socialist state, this harmony may not be due to the inherent capacity of such a régime to produce a persuasive unification of human desires, but merely to the elimination of everybody who ventures to disagree with the people in power. Similar civil wars and purges may very well occur in the United States and the countries of western Europe before they are fit to form an international socialist Union. As I am one of those who would doubtless be liquidated, it takes more self-sacrifice than I possess to view with equanimity this cheerful sequel to World War II. Even if dissentients are allowed to emigrate or slip away, they will have to live somewhere, and they will tend to increase opposition to the federation wherever they go. When the longed-for second Armistice has at last arrived, will there be no practicable road to world peace except through a long series of violent revolutions, mass exiles, and massacres?

Of course, it is possible that the present war will produce such extensive expropriation of private property that every state will be virtually socialistic when it ends. Then the nations may be able to slide into a socialist Union without any preliminary turmoil. Even so, it is rash to assume that socialism will automatically end war. Mr. Pritt argues that the inhabitants of a socialist state will not be aggressive because their government will produce all they need. This seems inconsistent with the occurrence of several great famines in Russia. Political and economic equality will not produce world-wide geographic equality. Even without rich men, there will be rich lands. The inhabitants of a fertile region may decline to stint themselves drastically in order to feed a famine-stricken state, and so the underfed people may surge outward into the golden wheatfields and green pastures of neighboring states.

> "The mountain sheep are sweeter,
> But the valley sheep are fatter;
> We therefore deemed it meeter
> To carry off the latter."

Even if your government gives you all you want now, this does not prevent you from wanting still more and perhaps persuading your government to find it beyond the frontiers. The disappearance of capitalism will remove some of the present causes of war, but others will still remain. In the present combat between Germany and Russia, both sides call themselves socialists, and certainly there is very little opportunity for private profits in either country. Future wars may result from conflicts of interest between different races or regions, between rice-eaters and meat-eaters, between clever people and plodders.

In order to adjust such conflicts peaceably, we shall need a more complex scheme than the constitution of the U.S.S.R. In spite of Mr. Pritt's praise, this does not offer a close parallel to a federation of Europe or the world. One of its member-states, Russia, contains three quarters of the area of the U.S.S.R. and two-thirds of the population. Under such conditions, one partner is likely to be predominant and the rest satellites. Even if such a system has worked satisfactorily within the Soviet Union, this tells us very little about the probable success of a greatly expanded socialist federation with several approximately equal large members. So if we proposed to set up an organization including, say, Great Britain, the Dominions, the United States, Germany, the U.S.S.R., China, and Japan, then even though they have all become socialistic states, still we shall have to draw on schemes like those of Lord Davies, Streit, and Bingham, in order to determine the best form of organization.

Our next question is, should the world unite in some way or other, or only Europe? It is significant that Mr. Pritt's telling objections to a proposal of federalism for the world are much weakened when applied to Europe. Here is a body of countries which have belonged for centuries to an intellectual and spiritual confederation, which form an economic unit, whose boundaries have lately become less important. There is sufficient likeness and pressure in this crisis to foster a desire for union, sufficient divergence in language and traditions to make them stop short of complete unity. A respect for law is strong in western Europe at least, and even the Balkans are probably not more lawless than our frontier states a century ago.

On the other hand, a union of Europe alone presents serious perplexities. Great Britain seems an essential member, but what are you going to do with the British Empire? If you bring in Russia, half of Asia comes in too, but her omission leaves her a potential disputer with definite interests in the Baltic and the Balkans. Non-European dependencies ought to be run by a world organization, not just European, if they are to be administered for their natives and their raw materials handled for the benefit of consumers everywhere.

In short, a European union seems feasible, and it will be desirable if it be subsidiary to some sort of world organization.

Finally, League or Union? Here I feel still more cautious, but I shall throw out a few ideas for what they are worth. I began my reading with a strong feeling that the League had hopelessly failed, and that Grenville Clark's plan of Union, which I already knew, was a better way out. The more I have read, the more I have found myself swinging toward something based on the League. With all its timidities (which Congress can often imitate) and its defects, the record of unspectacular achievement is much more impressive than I realized. The so-called technical services, in particular—health, labor, etc.—must not be abandoned. Perhaps they could be merely transferred to Mr. Streit's Union, but there is more to it than that.

In the first place, it is not fair to balance against a League with bad failures a Union with no failures. The Union never existed. We do not know what it would do. My guess is that Mr. Streit's Congress might have hesitated about sanctions against Italy in 1935 as much as the Council did, and applied them no better if it lacked an international police. I also surmise that the elected representatives from Italy or Germany in a Congress would have been *alter egos* of Mussolini and Hitler as much as their appointed delegates to Council or Assembly. A dictator can control elections easily, at least if there is no effective federal supervision, and would that have been likely?

Next, the League is a going concern, or at worst was such until Munich. You have something to start from. You know its weak points so as to remedy them. Its strong points have been operating for two decades. At least, we should be rather slow to junk it for something entirely new.

The parallel with our own Confederation and Union is tempting, but is it sound? American conditions were far more favorable to Union than are world conditions. Large areas lie outside a common tradition, and others have not developed a respect for law as we know it. A looser form of association may be appropriate, at least for some decades.

The failures of the League are not necessarily due to its structure. Causes hampered it which may not be repeated. There was its entanglement with a dictated peace—this time we may negotiate, especially if the dictators are previously replaced by democratic governments. The strains in the early years were terrific. Would the United States have survived if the Dred Scott case, secession, the recent depression, and several state dictators like Huey Long had all come within two decades after 1789? The League had to go through all that. Our Union had sixty years to become rooted before the first great strain of 1850. Finally, the League may not have worked because its members did not want very much to make it work. Rappard in his "Quest of Peace" (March 1, 1940) writes:

> "The nations which had been at war with each other . . . had never concluded a real peace in that they had never succeeded in regaining each other's confidence. . . . Those who . . . had won the World War and settled the terms of peace were unwilling to prolong those efforts and to exert their influence to insure the maintenance of those terms. . . . The present plight of Europe is due less to the excessive ambitions of the men of 1919 than to the excessive debility of their successors."

It seems possible then that we shall be wise to begin with what we have, the League of Nations. It will be wise to use its experience of twenty years with legislative sessions, executive sessions, a judicial tribunal, and numerous administrative bodies of high quality. Knowing what were the mistakes of the League, we have some ideas what to avoid. This may require drastic changes in the Covenant, and very likely some of these changes may approximate ideas suggested by Streit's Union and other schemes. For example, the League finances would be on a sounder basis if the contributions from member states were supplemented by some kind of League tax. This might conceivably be levied on all international movements of goods, money, and persons.

Getting away from details to a broad outlook on the problem of post-war international organization, the previous discussion suggests two points for the future.

In the first place, it is very important to avoid strains during the early years of the new international body. Whatever our impulses, there will be no time for vengeance. The world after the armistice will resemble a town which has to rebuild itself after a flood. The incompetents must be removed, but any other sort of punishment will be a luxury which we cannot afford. There will be too much else to do. The lesson of our own Reconstruction Period and Europe since November 11, 1918, is, then when a war is over, it ought to be over. Briand's words "Pour nous, c'est fini." ought to be spoken on the day of the armistice and not eight years afterwards. What I mean can best be illustrated by a letter from an English girl who has lived for two years in constant danger from air-raids. It was written on December 14, 1941:

> "Last night I heard on the wireless an excellent 'American Commentary' by Raymond Gram Swing, which traced the course of American public opinion during this first week. He described the U. S. as a nation at first staggered with rage and shame, but quickly recovering and now steadily determined. But there is, I think, yet another quality of mind in addition to courage and resolution and self-sacrifice that is even harder to acquire and maintain, but which is essential if the war and the peace are to be won. This is a certain gentleness—the negation of spite or anger or antipathy to the German people. I don't know how to describe it. It is well shown in Aeschylus' play 'The Persians.' written to celebrate the brilliant victory of democratic Greece over the great totalitarian Persian empire. It contains no noisy self-congratulation or boasting pride, but depicts the sorrow of the relatives of the Persian dead. To be dignified in victory is very hard. How I hope that both Britain and the United States will maintain till the end of the war the quiet sanity of Athens after Salamis, the reasoned strength and belief in the future."

Another way to avoid strains is the immediate freeing of economic life after the armistice, so as to produce on both sides a feeling of great relief that the war is ended. This time there must be no food blockade.

Also, there must be no raids, like those on Vilna and Fiume. No matter what the costs, those in charge of the peace must make everybody realize that fighting has got to stop. Perhaps frictions could be reduced by establishing a temporary *status quo,* say for twenty-five years, with a definite method for later adjustments.

Strains can be reduced by the restoration of normal life through rapid reconstruction on a great scale. International understanding might be increased if this were carried out cooperatively. For example, suppose some German workmen came over to help in England and *vice versa.* Each visiting group would soon realize that people very much like themselves had suffered in a common disaster. Who will pay for this vast work of reconstruction? The answer is simple, though perhaps unpalatable. Who pays for the war? For the most part, we do. I suspect that we must also bear a heavy share of the expense of reconstruction in order to avoid an infinitely greater outlay in preparation against a Third World War.

Secondly, no scheme is enough. The spirit is even more essential. Years ago André Siegfried remarked to me that the League of Nations lacked "Geist." It had no personality. To the ordinary man it was just a distant piece of machinery in Geneva. One strong reason for the success of the United States in the early years was that the nation was immediately brought before the eyes of every citizen through flags over post-offices, federal judges and officials in every state, naval vessels in harbors, and the government stamp on coins. In some such way, the new international body must become a reality for the common man everywhere. It would be very helpful if the League could fly its flag widely and take over a considerable number of everyday things like postage stamps and coinage. The League symbol should be put on all the great public works built during reconstruction. Its officials and benefits should be made generally visible. Recreation is an excellent way to make the League a drawing force. It might take over all youth hostels, which formed one of our most hopeful international organizations before the war. It might arrange international excursions at public expense, taking a leaf from the book of the Nazis and using these excursions for mutual understanding instead of nationalistic pride.

The spirit is all important. The new international organization requires a desire to make it work as well as a desire to start it. In this respect practically all the books I have read are at fault. They possess little emotional appeal. They lack the quality which shone so clearly in the speeches of Woodrow Wilson. We must make people everywhere want to join a world organization.

Some such organization must come into existence, for the alternative of perpetual defense and repeated total warfare is hideous. Still we must not minimize the difficulties. When the local contractor in the little Maine village where we go for the summer engages workmen from the next village, there is an outcry against the employment of "foreigners." This illustrates the frictions which must be overcome between inhabitants of different countries and different parts of the world. There is no simple solution. We must be patient and remember that cathedrals are rarely built by a single generation. We must know much—we must hope much.

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[1] Matthew Arnold, introduction to *Poems of Wordsworth* (Golden Treasury edition) vii (1879).

[2] This account of China is based on Owen Lattimore, *Inner Asian Frontiers of China,* 339–406, 419–425, 444–447 (1940).

[3] Joint Resolution of June 25, 1910, 36 Stat. 885.

[4] See Carl Becker, "Making Democracy Safe in the World," 31 Yale Review 433 (1942).

[5] 55 Harv. L. Rev. 561.

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THE LOWER PERMIAN INSECTS OF KANSAS. PART 9. THE ORDERS NEUROPTERA, RAPHIDIODEA, CALONEURODEA AND PROTORTHOPTERA (PROBNISIDAE), WITH ADDITIONAL PROTODONATA AND MEGASECOPTERA.

By Frank M. Carpenter

THE LOWER PERMIAN INSECTS OF KANSAS. PART 9. THE ORDERS NEUROPTERA, RAPHIDIODEA, CALONEURODEA AND PROTORTHOPTERA (PROBNISIDAE), WITH ADDITIONAL PROTODONATA AND MEGASECOPTERA.*

By Frank M. Carpenter

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Dr. Tillyard's sudden death in 1938 left unfinished his account of the Permian insects from the Elmo limestone in the Peabody Museum at Yale University. The unstudied specimens in that collection, mostly belonging to the Protorthoptera and related groups, have recently been turned over to me by the authorities of the Peabody Museum for identification and description. The present paper deals with the Caloneurodea contained in both the Yale and Harvard Collections, and with the Neuroptera, Raphidiodea, and part of the Protorthoptera (family Probnisidae) in the Harvard collection, the Yale specimens of these groups having already been described by Tillyard. I have also included here an account of some Protodonata and Megasecoptera in the Harvard collection which were not considered in my earlier papers on these orders.

Additional PROTODONATA

Since the publication of my previous account of the Protodonata from the Elmo limestone (1939), Professor R. C. Smith, of Kansas State College, has sent me a magnificently preserved hind wing of *Megatypus schucherti* Tillyard (family Meganeuridae). It was collected by two entomological students in the College, Mr. Otto Wenger and Mr. Floyd Holmes; the reverse of the fossil is in the Kansas State College entomological collection and the obverse in the Museum of Comparative Zoology.

Apart from doubtful fragments, *M. schucherti* has previously been known only from the holotype, a hind wing lacking the distal fourth of the wing and some details of venation (Tillyard, 1925). The new specimen is an absolutely complete hind wing, showing with perfect clarity all veins (Plate 1, figure 1). It is not only interesting as the largest entire wing yet found in the Permian, but it is also important because it enables us to complete our knowledge of the venation of this huge insect. The new wing is 195 mm. long and 40 mm. wide (maximum). This indicates that the total wing expanse was about 41 cm. or 16 inches. The holotype specimen, which was not quite complete, measured 165 mm. in length.[1]

Tillyard's restoration of the wing of *schucherti* (1925, fig. 5) is now seen to be incorrect in two respects. First, the wing is more slender apically than he assumed it to be; and second, the subcosta ends well before the apex of the wing, instead of at the apex, as he has drawn it. His figure of the actual type specimen is incorrect in that it has R4 + 5 (termed R3 in his paper) arising in the distal half of the wing, well beyond the level of the first fork of MA. Actually, R4 + 5 arises (in both the holotype and the new specimen) slightly before the middle of the wing, and directly above the fork of MA. In all except individual details the new wing has the same venation as the holotype.

One of the most interesting aspects of the new fossil is the presence of an oblique vein at the point of separation of R2 from R3. This is obviously the homologue of the vein (subnodus) described by Sellards in *Typus permianus* (1906, p. 253, figs. 4, 5). As I have already stated (1939, p. 38) such a vein has not previously been discernible in any Protodonata (*Megatypus* or *Typus*) in the Yale or Harvard collections from Elmo. It should be noted that there is no indication of the oblique vein "o" described by Sellards in *Typus*. The obliquity of this vein is almost certainly an individual trait.

Additional MEGASECOPTERA

The extinct order Megasecoptera is not uncommonly represented in certain Carboniferous strata of Europe, but until comparatively recently it has not been found in Permian rocks. The insects which Tillyard originally described from the Elmo limestone as members of a new order, Protohymenoptera,

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* This investigation has been aided by a grant from the Permanent Science Fund of the American Academy of Arts and Sciences.

[1] The width of the holotype wing was given by Tillyard as 94 mm., but this is an error; it should have been 39 mm.

are now generally recognized as close relatives of the Megasecoptera and as constituting merely a suborder of the Megasecoptera. In his last discussion of the affinities of the Protohymenoptera, Tillyard (1936) expressed agreement with this view, though claiming it to be a matter of personal choice whether the group be regarded as a suborder or an order. The Protohymenoptera from the Elmo limestone contained in the Harvard collection have already been described (Carpenter, 1931a, 1931b, 1933, 1939).

Apart from the Protohymenoptera, the order Megasecoptera is represented in the limestone by several species which are more closely related to the Eumegasecoptera[2] than to the Protohymenoptera. One of these, *Elmoa trisecta* Tillyard, was recognized by Tillyard as a Megasecopteron and placed by him in a new family, Elmoidae. Two other species which he described from the formation (*Martynovia insignis* and *Martynoviella protohymenoides*) are, in my opinion, also Megasecoptera, though they were considered by him to be Neuroptera, belonging to the suborder Sialoidea (Megaloptera). Unfortunately, not only was each of these three species based upon a single wing, but the type of *Elmoa trisecta* consisted of a basal fragment of a wing. Had these specimens been more nearly complete, Tillyard would undoubtedly have recognized the very close relationship between *Elmoa*, which he placed in the Megasecoptera, and the Martynoviidae, which he assigned to the Neuroptera. The evidence for my conclusion on the affinities of these fossils is derived from a study of the specimens in the Harvard collection and will be considered below, after a description of the insects.

Suborder EUMEGASECOPTERA

Family ELMOIDAE

Wings subequal; membrane glassy. Fore wing: Sc terminating before or at mid-wing; costal veinlets few and weakly developed; Rs arising before mid-wing; M coalesced proximally with R; MA and MP present; MA not coalesced with Rs or R1; CuA coalesced proximally with stem R + M; two anals present; pterostigma apparently absent. Hind wing: narrow basally, but broader near the middle than the fore wing; Sc closer to R than in fore wing; rest of venation as in fore wing. Almost nothing is known of the body structure.

At present the family consists of one genus.

Genus *Elmoa* Tillyard

Elmoa Tillyard, 1937, Amer. Journ. Sci. **33:** 82.

Fore wing: long and moderately slender; costal space of moderate width; Sc terminating on R1 before mid-wing; R1 unbranched; pterostigma absent or at most very weakly formed; Rs with at least three terminal branches; R, M and CuA separating at the same point; MA probably unbranched; MA joined to Rs by a weak cross-vein shortly after the origin of the latter; MP forked; CuA unbranched; cross-veins few and weakly developed. Hind wing: similar to the fore wing in venation, except for differences noted under the account of the family.

Genotype: *Elmoa trisecta* Till.

Elmoa trisecta Tillyard

Figure 1

Elmoa trisecta Tillyard, 1937, Amer. Journ. Sci. **33:** 84.

Fore wing: length, 12 mm.; width, 3.2 mm.; 3 or 4 strong costal veinlets at base, above stem R+M, and 1–3 weaker ones more distal along Sc; a few oblique veinlets between R1 and costal margin, especially distally; Sc terminating beyond origin of Rs; stem R + M arched; R4 + 5 long, arising before mid-point of Rs; R2 and R3 at most half as long as R4 + 5; MA arising proximally to origin of Rs; MP forked to about half its length; CuP not forked, but connected to hind margin by a long cross-vein; 1A remote from hind margin, connected to it by at least one cross-vein; 2A very short.

Hind wing: length, 12 mm.; width, 4 mm.; more nearly oval than the fore wing; costal space as wide as in fore wing, with similar veinlets; Sc not quite so long as in fore wing and nearer R+ M than in fore wing.

The body structure is preserved in one specimen (No. 4591ab); this shows only the thorax, part of the head, and a small piece of the abdomen. The head is small (1.5 mm. long) and broad, and apparently has prominent eyes.

Holotype: No. 15591ab, Peabody Museum, Yale University. This consists of the basal third of a hind wing, not a fore wing, as stated by Tillyard.

In the Harvard collection there are eight specimens of *trisecta*, of which six are from the upper layer of the limestone: no. 4591ab, a complete insect, showing both pairs of wings; the fore wings overlap part of the hind pair, but the two pairs are readily distinguished. No. 4606ab, a very nearly complete fore wing, well preserved; no. 4595ab, 4607ab, each consisting of the proximal third of a fore wing; no. 4590ab, a complete and excellently preserved hind

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[2] The order Megasecoptera includes the two suborders Eumegasecoptera and Protohymenoptera (Carpenter, 1933).

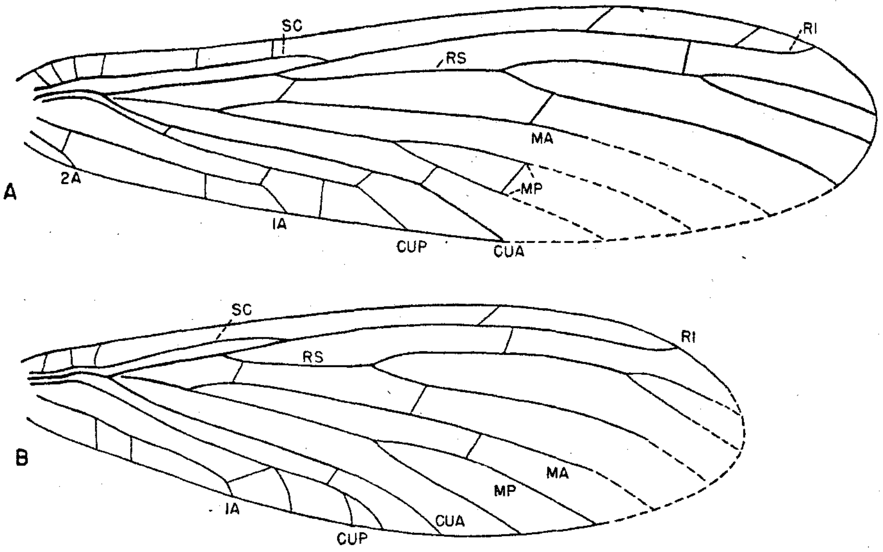

Figure 1. *Elmoa trisecta* Till. A, fore wing: drawing based mainly on specimen no. 4604, Mus. Comp. Zool. B, hind wing; drawing based chiefly on specimen no. 4590, Mus. Comp. Zool. Sc, subcosta (concave); R1, radius (convex); Rs, radial sector (concave); MA, anterior media (convex); MP, posterior media (concave); CuA, anterior cubitus (convex); CuP, posterior cubitus (concave); 1A, 2A, anal veins.

wing; and nos. 4592ab, 4593, 4594ab, all hind wings, more or less complete. These specimens were collected by F. M. Carpenter at the Harvard quarries at Elmo.

Tillyard's figure of the base of the hind wing of this species (1937, fig. 1) is incorrect in two important respects. The subcosta terminates on R1 just beyond the origin of Rs, instead of continuing for a considerable distance beyond this point, as he has drawn it. The wings of nearly all specimens of *trisecta* are wrinkled (as in the Protohymenoptera of the Elmo limestone) and apparently one of these wrinkles was confused by him with the end of Sc. He has also drawn MA as forked shortly beyond its origin; but this fork does not show in the type specimen or in any of the fossils in the Museum of Comparative Zoology. In none of the specimens of *trisecta* which have been found is MA preserved to the actual wing margin, but the missing part is so short that it seems almost certain that this vein was unbranched.

The Affinities of the Elmoidae

Although *Elmoa* possesses a number of characteristics foreign to the Carboniferous and most Permian Megasecoptera, I believe with Tillyard that it belongs to this order. All of the Eumegasecoptera previously known have possessed a petiolate or subpetiolate wing. The relatively broad wing base of *Elmoa* therefore suggests that the family which it represents was more generalized than other known Megasecoptera. As Tillyard has proposed, the Elmoidae were probably Permian derivitives of a group of Megasecoptera which must have existed well back in the Pennsylvanian Period. The short subcosta of *Elmoa*, however, is a specialization not previously found in any Eumegasecopteron, though a similar subcosta occurs in the Protohymenoptera.

Of particular interest in connection with the affinities of *Elmoa* is the difference in the shape of the fore and hind wings. The complete specimen in the Harvard collection shows conclusively that the broader wing is the hind one. This is consistent with the condition which occurs frequently throughout the Megasecoptera as a whole, including such slender winged types as *Foriria maculata* Meunier, from the Carboniferous of Commentry.

So far as the Permian is concerned the following family, Martynoviidae, seems to be the one most closely related to the Elmoidae.

Family Martynoviidae

Wings subequal; membrane glassy. Fore wing: Sc terminating on R1 at about mid-wing; costal veinlets few in number; pterostigma weak, but extensive, the area between R and the costal margin beyond the end of Sc being slightly thickened and pigmented; Rs arising before mid-wing; M coalesced basally with R; MA and MP present, MA coalesced with Rs; Cu coalesced with R + M basally; two or

three anal veins present. Hind wing: much broader than the fore wing, costal space slightly broader than that of fore wing; venation like that of the fore wing, except that the pterostigma is absent or very weakly formed at most. The body structure is unknown.

This family was originally established by Tillyard (1932) for two genera, *Martynovia* and *Martynoviella*. In a later paper (1937) he also placed here the genus *Promartynovia*, based upon a single wing fragment (*venicosta* Till.). Better and more nearly complete specimens of the latter species in the Harvard collection convince me that *Promartynovia* is really a Protorthopteron. Tillyard himself suggested that the precostal area in *Promartynovia* was probably a remnant of a formation carried over from a Protoblattoid ancestor. The genus *Promartynovia* will accordingly be considered in the following part of this series of papers.

For reasons which will be given below, I consider the genus *Martynoviella* to be synonymous with *Martynovia*, which thus becomes the only known genus in the family.

Genus *Martynovia* Tillyard

Martynovia Tillyard, 1932, Amer. Journ. Sci. **23:** 13.
Martynoviella Tillyard, 1932, ibid., **23:** 17.

Fore wing: long and moderately slender; costal space of moderate width basally, but narrowed above the origin of Rs; R1 close to the costal margin distally, unbranched; Rs with from 3–5 terminal branches; M separating from stem R + M at about the point of divergence of CuA from R + M; MA, MP, CuA and anals unbranched; cross-veins few in number. Hind wing: similar to the fore wing, except for differences noted under the family.

Genotype: *Martynovia insignis* Till.

At present two species of this genus are known, *insignis* Till. and *protohymenoides* Till. The latter is the genotype of *Martynoviella*, which I have synonymized here with *Martynovia*. In regarding these two species as representatives of different genera, Tillyard was unaware that one of them (*insignis*) was based on a hind wing, and the other on a fore wing. Although cognizant of the similarity of their venation, Tillyard was led to place them in separate genera by the difference in wing shape. Actually, of course, this difference is due to the fact that the fossils do not represent homologous wings.

Martynovia insignis Tillyard

Figure 2

Martynovia insignis Tillyard, 1932, Amer. Journ. Sci. **23:** 15.

Fore wing: length, 12.5–20 mm.; width, 3–4.7 mm. Costal margin arched basally, slightly concave just beyond the origin of Rs; costal space broad basally,

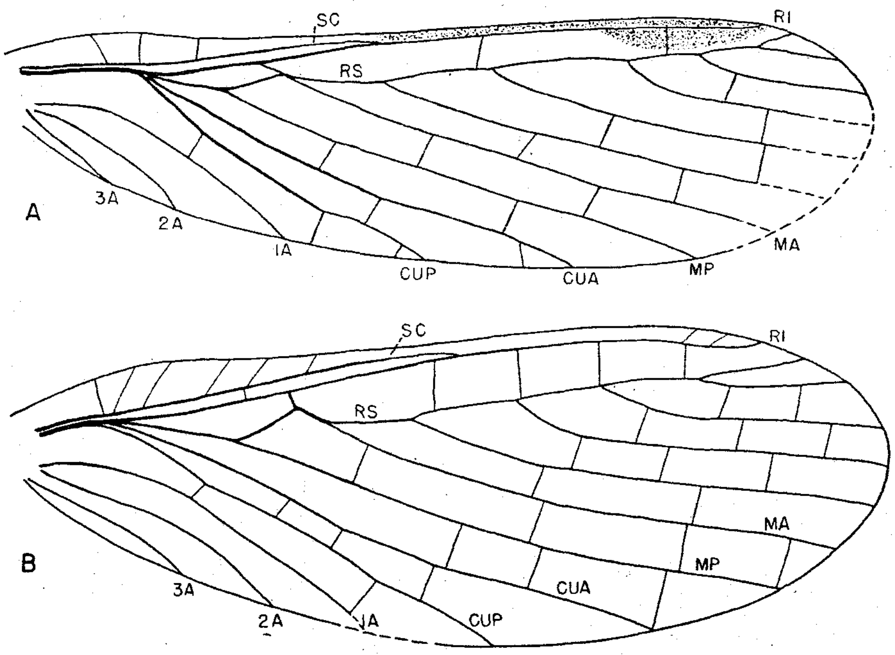

FIGURE 2. *Martynovia insignis* Till. A, fore wing; drawing based chiefly on specimen no. 4601, Mus. Comp. Zool. B, hind wing; drawing based mainly on specimen no. 4604, Mus. Comp. Zool., and the holotype. Lettering as in figure 1.

but very narrow before end of Sc; several prominent costal veinlets; Rs with from 4–5 branches; usually two cross-veins between each of these and MA and MP; CuA and CuP separating at about the same level as the point of divergence of Rs from M; 1A and 2A well developed; 3A sometimes present near base of wing. Cross-veins strongly developed. Hind wing: length, 12.5–20 mm.; width, 4.2–6 mm. Costal area broader than in fore wing and not so markedly concave; venation as in the fore wing. The hind wing appears to lack a pterostigma; its absence in the holotype (hind wing) can hardly be due to its failure to be preserved, since the wing is in excellent condition.

Holotype: no. 5423, Peabody Museum, Yale University. This is a hind wing, not a fore wing, as stated by Tillyard.

In the Harvard collection there are three specimens of this insect, all from the upper layer of the limestone and collected at Elmo by F. M. Carpenter: no. 4600ab, and no. 4601ab, complete and well preserved fore wings; and no. 4604ab, a hind wing, about two-thirds complete, lacking only a part of the costal area and most of the actual posterior margin.

Tillyard's drawing of the wing of *insignis* (1932, fig. 5) is incorrect in two important respects: in the first place, the "obsolescent costal vein" which he represents in solid lines in one illustration (fig. 5) and in dotted lines in another (fig. 6), does not exist in the type nor is it present in the Harvard specimens. Tillyard himself was apparently doubtful of its presence, for he states (p. 16) that he was unable to satisfy himself of the course of this vein. Such a vein does not occur in the Megasecoptera, though it is found in many Neuroptera. In the second place, the "obsolescent Cu2," represented in his figure by dotted lines, is also not present in any of the specimens, including the type. Of this vein he states that he could not be quite certain even of its existence. I am at a loss to explain why Tillyard did not recognize as CuP (Cu2) the vein which he has designated Cu1b; this is concave, as CuP should be, and it occupies the normal position of this vein.

Since no complete specimens of *insignis* or *protohymenoides* are known, I have based my conclusion on the identity of fore and hind wings of these two species on comparisons with the wings of *Elmoa*. It is at once clear from an examination of the two wings shown in figure 2 that their venation is identical, the only differences between them being in wing shape. Two possible interpretations of these wings can be made; they might represent two species of *Martynovia*, one slender and the other broad; or they might be fore and hind wings of the same species. The latter interpretation is the one which seems certainly correct, in view of the wing structure of *Elmoa*, the fore and hind wings of which show the same differences as those existing between the wings in figure 2. Furthermore, it is also apparent from the condition in *Elmoa* and other Megasecoptera that the broader of the two wings is the hind one.

Martynovia protohymenoides (Tillyard)

Figure 3

Martynoviella protohymenoides Tillyard, 1932, Amer. Journ. Sci. **23**: 18.

Fore wing: length, 12.5–17 mm.; width, 3–3.5 mm.; much more slender than that of *insignis;* costal margin only slightly arched basally and almost straight beyond this part; costal space not narrowed until about mid-wing; pterostigma as in *insignis* though not extending so far proximally; Sc more remote from R1 than in *insignis;* costal veinlets and other cross-veins apparently fewer in number than in *insignis;* Rs with 3–4 branches; CuP separating from R + M much further proximally than the point of separation of CuA; 3A is not preserved in any specimen; cross-veins very weak. Hind wing unknown.

Holotype: No. 5424, Peabody Museum, Yale University. This consists of a nearly complete fore wing; only about the proximal fifth of the wing is missing.

In the Harvard collection there are three specimens of *protohymenoides*, all from the lower layer of the limestone and collected by F. M. Carpenter: no. 4597ab, the distal half of a fore wing; no. 4599ab, a complete and well preserved fore wing; and no. 4558ab, a nearly complete fore wing.

This insect is obviously very similar to *insignis* and differs from it in such minor characteristics as the shape of the wing and of the costal space. In separating *protohymenoides* from *insignis* generically, Tillyard was misled by the fact that he had only the fore wing of one species and the hind wing of the other. His figure of the type of *protohymenoides* (1932, fig. 7) is not entirely correct. He has drawn more of the proximal part of the wing than is actually preserved and his restoration of the base of the wing does not agree with the structure shown in the Harvard specimens. The pterostigma is faintly but

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[8] Martynov (1938b, p. 39), without having seen any specimens of Martynoviidae, suggested on the basis of the published figures that Tillyard's Cu1b (CuA2) was really CuP.

clearly indicated in the holotype, though it is not mentioned by Tillyard. It is more distinctly preserved in one of the Harvard specimens (no. 4598).

THE AFFINITIES OF THE MARTYNOVIIDAE

As previously mentioned, the family Martynoviidae was placed by Tillyard in the suborder Sialoidea of the order Neuroptera. Unfortunately, Tillyard gives no reasons for his decision that *Martynovia* and *Martynoviella* were Neuropterous, apparently assuming that their systematic position was obvious. However, in his discussion of the phylogenetic relationship between the Martynoviidae and the existing Sialoidea, Tillyard concluded that the Martynoviidae were in no sense ancestral to any Recent members of the order. Apparently, therefore, he recognized the existence of great differences between the living Sialoidea and the Martynoviidae. He explained these differences by the assumption that the Martynoviidae were an end group of Neuroptera which arose from Carboniferous stock. In my opinion, however, the differences are simply due to the fact that the Martynoviidae are not at all related to the Neuroptera or to any other holometabolous insects.

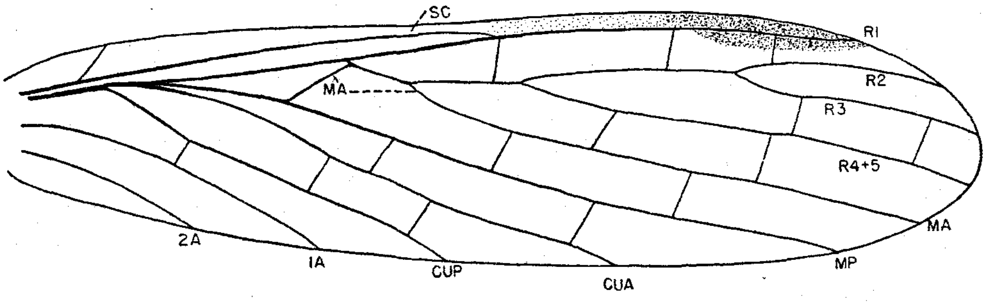

FIGURE 3. *Martynovia protohymenoides* Till. Drawing of fore wing, based chiefly on specimen no. 4599, Mus. Comp. Zool. Lettering as in figure 1.

A comparison of the wings of the Martynoviidae with those of the Megaloptera shows that whatever resemblances exist (such as the branching of Rs) are entirely superficial; whereas the numerous differences are of a more fundamental type. The short subcosta of the Martynoviidae, for example, is in direct contrast to the long one characteristic of the Megaloptera (Sialoidea), in which the distal part of the subcosta is always associated with the radius in the pterostigmal region. Another essential difference is the presence of the extensive and thickened pterostigma in the Martynoviidae; no such structure is present in the Sialoidea. Without enumerating further differences of this sort, we may conclude, I believe, that the Martynoviidae do not belong with the Neuroptera and have no relationship with them. This view has already been expressed by Martynov (1938b), though he did not present reasons for his conclusion.

We are next faced with the problem of determining the true affinities of the Martynoviidae. Of the Permian insects now known the Elmoidae seem to be the closest to them, in wing structure, at least. All of the main veins have similar origins in both groups, and the short subcosta occurs in both. The chief differences between them are in the coalescence of MA and Rs and the presence of a pterostigma in the Martynoviidae; in the Elmoidae MA is free from Rs and a true pterostigma is apparently absent. However, these two characteristics are the ones *which distinguish the Elmoidae from the other known families of Megasecoptera.* Consequently, the Martynoviidae are intermediate in wing structure between the Elmoidae and certain other Megasecoptera. It is my conviction, therefore, that the Martynoviidae are Megasecopterous, belonging to the suborder Eumegasecoptera; and that their systematic position is not far from that held by the Elmoidae.

The pterostigma of the Martynoviidae is of much interest in this connection. As already noted, this pterostigma, although only slightly thickened, is very suggestive of that in the suborder Protohymenoptera (Megasecoptera). In the latter insects, the area between R1 and the costal margin is thickened and pigmented for a considerable distance. I do not believe, however, that the similarity of the pterostigma in these two groups is sufficient to justify the reference of the Martynoviidae to the Protohymenoptera, for they have much more in common with the Eumegasecoptera. Nevertheless, they were probably not far from the line which gave rise to the Protohymenoptera. Incidentally, I wish to point out that although no true pterostigma has been seen in the wings of the Carboniferous Megasecoptera, one might well have been present; all or nearly all of the Carboniferous species are preserved in black or very dark gray shale, in which such detailed structures as a pterostigma are obscured.

Tillyard was obviously aware of the similarity between the Martynoviidae and the Protohymenoptera, for he says of *Martynoviella* (1932, p. 23): "There is here, surely, something more than a purely chance resemblance to Protohymenoptera. While it can scarcely be doubted that this genus is Sialoid, the strongly formed veins and cross-veins, with the obsolescent chaetotaxy, the general scheme of venation and the curious arrangement of the cross-veins, strongly suggest the possibility of an affinity between the two orders. And if, as may be possible (though I cannot accept Carpenter's supposed proof of it, of which more later) the Protohymenoptera are descended from Megasecoptera, then we may also have to reconsider Handlirsch's view that the Neuroptera are similarly derived." The latter part of this statement is of much interest, since four years later (1936) Tillyard accepted in full the thesis that the Protohymenoptera were Megasecopterous (1936, p. 450). I do not for a moment believe, however, that we are thus obliged to give serious consideration to the derivation of the Neuroptera from such highly specialized insects as the Megasecoptera. As Tillyard himself pointed out (1932, p. 29), if there is one thing that appears certain it is that the two orders Mecoptera and Neuroptera have come from a common stem, and that this type must have combined in itself the more archaic characteristics of both the Meropoidea (Mecoptera) and Sialoidea. Such an ancestor is almost certain to be found among the Orthopteroids (probably Protorthoptera), not among the Megasecoptera.

Martynov (1938b), who has expressed doubt of the Neuropterous affinities of the Martynoviidae, has suggested that the family might be allied to the Archodonata, an order established by him for certain Permian insects related to the Odonata. The additional fossils described in the present paper, however, appear to eliminate this view, which was in fact proposed by him merely as a possibility, pending the study of further specimens of Martynoviidae.

Order NEUROPTERA

The order Neuroptera is very sparsely represented in the Elmo limestone. There are but two specimens unquestionably referable to this order in the Yale collection and only nine in the Harvard collection. These eleven specimens are of much significance, however, since they constitute the earliest geological record of the order.

It is a fact well known to entomologists that because of their great diversity of structure the Neuroptera defy a concise definition. Even the wing venation in the order is of such a bewildering variety that taxonomists have found it impossible to draw up venational limits of the group. This diversity of venation leads to a serious problem in the case of the fossil Neuroptera, of which only the wings are usually preserved. At least some uncertainty necessarily attends the determination of isolated wings as Neuroptera, especially specimens from Palaeozoic strata. I emphasize this here because I am convinced that several of the insects from the Elmo limestone which Tillyard has described as Neuroptera are not even related to the order; and consequently that the conclusions which he has based on these specimens are not valid.

Four of the Neuroptera which Tillyard described from the Yale collection were placed by him in the suborder Planipennia (Neuroptera, s. s.) and four others in the suborder Sialoidea (Megaloptera). The following list includes all of these insects:

Suborder PLANIPENNIA
  Fam. PERMOBEROTHIDAE
    Permoberotha villosa Till. (1932)
    Permoberotha convergens Till. (1937)
    Dictyobiella nervosa Till. (1937)
    Permobiella perspicua Till. (1937)
Suborder MEGALOPTERA (Sialoidea)
  Fam. Choristosialidae
    Choristosialis enigmatica Till. (1932)
  Fam. Martynoviidae
    Martynovia insignis Till. (1932)
    Martynoviella protohymenoides Till. (1932)
    Promartynovia venicosta Till. (1937)

A study of both Yale and Harvard specimens of these species has convinced me that none of those described as Sialoids are really Neuropterous. The genera *Martynovia* and *Martynoviella* belong, in my opinion, to the order Megasecoptera; the reasons for this conviction have already been given above, in the account of additional Megasecoptera. The genus *Promartynovia*, which was based upon a small fragment of a wing, is clearly Orthopteroid; the evidence for this conclusion has been obtained from several complete wings in the Harvard collection and will be discussed in the subsequent paper in this series. *Choristosialis* should, I believe, be regarded as Mecopterous until evidence to the contrary has been found. The unique specimen on which the genus was established consists of less than half of one wing. Tillyard himself expressed some doubt of the Neuropterous affinities of this insect, pointing out that it had certain Mecopterous features, such as the dichotomous branching of Rs and M. The latter seems to me to have far more significance than the presence of possible Sialoid characteristics, such as the costal veinlets, which incidentally are also present in the generalized Mecoptera (suborder Protomecoptera). If *Choristosialis* were regarded as a Sialoid, it would be the only representative of the group in the Lower Permian; hence, in view of the incompleteness of the type specimen and the unquestionable existence of true Mecoptera in the Lower Permian, I prefer to consider it a Mecopteron.

Of the insects which Tillyard described as Planipennia, *Permobiella* is beyond doubt, as already shown by Martynov (1938a, 1938b), a relative of the Orthopteroid family Caloneuridae, recently placed by him in a new order, Caloneurodea. My account of this genus, with descriptions of related genera, will be found below under that order. The family Permoberothidae, however, almost certainly belongs to the Planipennia. Only one valid species of this family, *Permoberotha villosa* Till., has so far been found in the Elmo limestone, and if its affinities have been correctly determined, it is the oldest record of the order Neuroptera.

The venational terminology used in the following account of the Permoberothidae requires an explanation. In 1928 and again in 1932 Martynov expressed his conviction that the vein previously identified as the media in most existing Neuroptera was in reality only a posterior branch of the media (i. e., MP), and that the anterior branch had been identified as part of the radial sector. Tillyard in his first paper on the Neuroptera of the Elmo limestone (1922) accepted this interpretation and attempted to apply it to *Permoberotha*. The lettering of the veins in his drawing of the wing follows this terminology, but through some oversight his description of the venation in the text gives a different interpretation, more nearly following that of Comstock (1918). In his second paper (1937) on the Neuroptera of the Elmo limestone, Tillyard rejected Martynov's interpretation, which he had previously accepted, and returned to Comstock's view, so far as the radial sector and the media were concerned. But he did this *solely* on the evidence (1937, p. 102) which he thought was provided by another Neuropteron from the Elmo deposit, *Permobiella perspicua* Till.; this incomplete wing he believed to be a Planipennian "reduced to its lowest terms." Unfortunately, he was far wrong in his determination of the affinities of *Permobiella*, for, as Martynov has observed (1938a, 1938b), it belongs without doubt to the Caloneuridae, an Orthopteroid family which Tillyard apparently overlooked completely when he described the fossil. Hence, Tillyard's rejection of Martynov's concept of the Neuropterous venation was based on evidence which really did not exist. Since I have found, as indicated elsewhere (1940), that Martynov's interpretation explains very satisfactorily the venation of the existing Neuroptera, I have used it here.

Suborder PLANIPENNIA (Neuroptera, s. s.)

Family PERMOBEROTHIDAE

Wings subequal. Fore wing: costal area broader than in hind wing; Sc terminating on costal margin, a series of costal veinlets connecting it to the anterior margin; pterostigma absent; Rs arising from R near the base of the wing; MA coalesced with Rs for a short distance proximally, then continuing as a nearly straight vein almost to the very apex of the wing; MP coalesced proximally with CuA for a short distance, then continuing close to MA and parallel to it; between MA and MP there is a distinct groove, as in Recent Hemerobiidae and other families of Neuroptera; Cu forking at base into CuA and CuP; CuA coalesced with MP for a short distance; CuA2 arising before the separation of MP from CuA; CuP is a faint but distinct, straight vein. Hind wing: Sc close to R and terminating on R1 not far from mid-wing; Rs arising from R as in fore wing and coalesced with MA for a greater interval than in the fore wing; Rs forked as in the fore wing; MA, MP, CuA and CuP essentially as in the fore wing; groove present between MA and MP.

Little is known of the body structure: the abdomen was slender and terminated in a pair of short cerci.

The family Permoberothidae is so far represented by only one genus.

Genus *Permoberotha* Tillyard.

Permoberotha Tillyard, 1932, Amer. Journ. Sci., **23**: 24; 1937, ibid., **33**: 108

Dictyobiella Tillyard, 1937, ibid., **33**: 104

Fore wing: slender; costal area narrow basally, but broadened above the origin of Rs; recurrent humeral vein absent; costal veinlets not forked; Rs forked at about mid-wing or beyond, its branches somewhat zigzagged; CuA1 forked at least once; 2A terminating on 3A. Cross-veins are numerous and not arranged in gradate series. Hind wing: costal space with well developed veinlets; Rs forked as in the fore wing; 2A terminating on wing margin; cross-veins as numerous as in the fore wing, not in gradate series.

Genotype: *Permoberotha villosa* Tillyard. This is the only species of the genus known at present.

Permoberotha villosa Till.

Figure 4

Permoberotha villosa Tillyard, 1932, Amer. Journ. Sci., **23**: 25
Permoberotha convergens Tillyard, 1937, ibid., **33**: 109
Dictyobiella nervosa Tillyard, 1937, **33**: 105

Fore wing: length, 9 mm.; width, 2.8 mm. Anterior margin slightly concave; 10–12 costal veinlets, and 7–9 between R1 and the costal margin; a single well developed cross-vein between Sc and R just before the origin of Rs; forking of Rs somewhat variable; in the holotype R2 + 3 and R4 + 5 separate in the distal third of the wing, but in one of the Harvard specimens (No. 4605) they separate before mid-wing; in none do either of these branches of Rs apparently divide again; CuA1 shows little variation in forking; in all clearly preserved specimens each main branch of CuA1 forks again at the margin. In the holotype, an incomplete wing, there are about 56 cross-veins; and in the best of the Harvard specimens (No. 4605) there are 64 cross-veins. The fore wing had well developed macrotrichia on the main veins, their large sockets being visible in all specimens. Microtrichia are discernible on the fore wing of the holotype.

Hind wing: length, 8 mm.; width, 2.8 mm. More oval than fore wing and much broader distally than basally; Sc closer to R1 than to the anterior margin, with about 16 well developed costal veinlets between Sc and the margin, and between R1 and the margin. The branching of Rs and CuA1 shows the same variation as in the fore wing.

The body structure of this insect is very incompletely known and is preserved only in the holotype of *Dictyobiella nervosa* (no. 15592, in Yale collection). The length of the entire body is 6.5 mm., a little less than that of the fore wing. The abdomen is slender, 4 mm. long and 1 mm. wide. Very little can be made out of the head and thorax; Tillyard has described the shape of the head, eyes and clypeus from this fossil, but I have been unable to identify these structures. The abdomen terminates in a pair of cerci. These were not entirely exposed when Tillyard described the insects and are therefore incorrectly depicted in his figure (1937, fig. 9a). They are much longer than he thought and consist of 4 or 5 segments. There is no terminal bristle, as drawn by him; the structure which he interpreted as a bristle was an exposed part of the rest of the cercus.

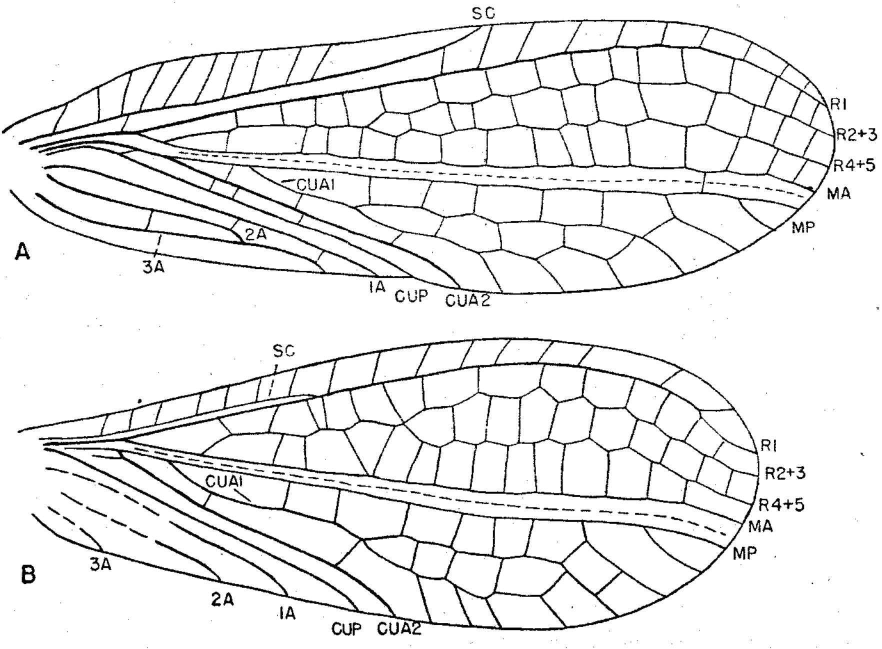

FIGURE 4. *Permoberotha villosa* Till. A, fore wing; drawing based mainly on specimens no. 4605, Mus. Comp. Zool., and the holotype. B, hind wing; drawing based mainly on specimen no. 4575, Mus. Comp. Zool. R2 + 3 and R4 + 5, branches of Rs; other lettering as in figure 1.

Holotype: No. 5426 and its counterpart (15595) Peabody Museum, Yale University.

In the Harvard collection there are nine specimens of this insect, nos. 4573–4580 and 4605. Six of these are from the upper layer; four (4572, 4576, 4578, 4579) are hind wings and the rest are fore wings. All were collected by F. M. Carpenter in the Harvard quarries at Elmo, Kansas, in 1927, 1932 and 1935.

Permoberotha convergens Till. was based upon the counterpart (obverse) of the holotype of *villosa.* This is not readily apparent from Tillyard's figures of these two insects (Tillyard, 1932, fig. 11; 1937, fig. 10), but when I examined the specimens themselves at the Peabody Museum, I was struck by the exact correspondence of cross-veins; and on placing the two fossils together I found that they fitted perfectly. Tillyard's figure of the obverse specimen (*convergens*) is very inaccurate and highly diagrammatic. The numerous cross-veins which he shows between CuA, CuP and the anal veins simply do not exist in the fossil.

Dictyobiella nervosa is likewise a synonym of *villosa.* Tillyard's figure of its wing does not indicate this, but, as he mentions, his drawing was a composite one, based upon both fore and hind wings. The hind wing venation is represented by the short Sc and the fore wing venation by the structure of Rs. The cubitus is incorrect for either wing and the zigzagged R4 + 5 (Tillyard's notation) shown in his figure and used for generic diagnosis, does not exist in the specimen. In the type specimen of *nervosa* the two fore wings and one hind wing are superimposed so that most of the veins cannot be distinguished, though enough is clear to enable recognition of the venation of *villosa.* The second hind wing is preserved out-stretched to one side and its venation is distinct except at the base. It is identical with the hind wing shown here in figure 4, except for the position of cross-veins and other individual features. Unfortunately Tillyard assumed that the short Sc and other hind wing structures were characteristic of both wings and made them generic. It is noteworthy that *Permoberotha villosa* is the only Permian Neuropteron so far described of which both fore and hind wings are known.

Relationships of the Permoberothidae

Since *Permoberotha* is geologically the oldest Neuropteron known, its phylogenetic position is of much interest. Tillyard was of the opinion that there was "no valid reason why the genus *Permoberotha* should not be regarded as representative of the ancestral stem of the Berothidae" (1932, p. 28). I do not agree with this view. In fact, the difference between the wings of the Berothidae and Permoberothidae are so great I find it difficult to make comparisons. The following summary lists the points of difference between these wings which seem to me to eliminate any possibility of the relationship suggested by Tillyard.

1. *Permoberotha* lacks any sign of a pterostigma. Since a pterostigma of some kind is present in all the Hemerobioidea, including the Berothidae, the absence of it can only be regarded as a specialization—unless of course we consider the very improbable supposition that *Permoberotha* is ancestral to all Hemerobioidea.
2. The subcosta of *Permoberotha* terminates at about mid-wing. In the Berothidae and all other existing Neuroptera (Planipennia), as far as I am aware, the subcosta terminates nearly at the apex of the wing.
3. The radial sector of *Permoberotha* consists of only two branches, in contrast to the multibranched radial sector of the Berothids and nearly all existing Planipennia.
4. The branches of Rs and Cu are strongly zigzagged, a specialization which is not found in any Berothid.
5. MA is unbranched and close to MP in *Permoberotha;* the proximity of MA and MP is a specialization not known in existing Neuroptera.
6. MP in *Permoberotha* is coalesced basally with CuA in both wings, another specialization which is not known to me in existing Planipennia.
7. Sc in the hind wing of *Permoberotha* is very short, terminating on Rl well before the middle of the wing; such a structure of Sc is unknown in Recent Neuroptera.

These differences have led me to the opinion that the family Permoberothidae is much too highly specialized to be ancestral to the Berothidae, or for that matter to any other existing family of Neuroptera. It is more likely a specialized offshoot of a group of Upper Carboniferous Neuroptera, having little phylogenetic relationship with existing members of the order. This conclusion is substantiated by a comparison of *Permoberotha* with the Upper Permian Neuroptera which have been described from Russia and Australia (Martynov, 1932; Tillyard, 1926). All of these Upper Permian species, of which seventeen have been described, are far more generalized than *Permoberotha* and show numerous characteristics found in Recent families, such as the Berothidae, Osmylidae, and Psychopsidae. The Permoberothidae are certainly far removed from these other Permian types.

The real significance of *Permoberotha* is not to be found in the evidence it provides for the relationship or evolution of existing Neuroptera; but (provided it is a Neuropteron) in the evidence it furnishes that the order had been established long enough by the time of the lower Permian to include such highly specialized members.

Order RAPHIDIODEA

A single species of Raphidiodea, *Permoraphidia americana*, was described by Tillyard from the Elmo limestone in 1932. This insect is obviously a very rare one in the formation; the holotype is the only specimen of it in the Yale collection and there are but six additional specimens in the Museum of Comparative Zoology. An undescribed species of the same genus is also present in the Harvard collection. These new fossils fully substantiate Tillyard's conclusion on the affinities of the Permoraphidiidae and add materially to our knowledge of their structure.

Family PERMORAPHIDIIDAE

Wings subequal; the membrane lacks microtrichia and apparently macrotrichia, but it is not glassy, as in the existing Raphidiodea. Fore-wing: a recurrent humeral vein, resembling that of some Neuroptera, is present; this vein may be a submarginal costa, as it was interpreted by Tillyard. Costal veinlets well developed and about as numerous as in Raphidiidae; pterostigma well developed, traversed by several cross-veins; R1 unbranched; Rs arising at about mid-wing, with at least two branches; M coalesced with R basally and with CuAl for a short distance, the free piece of CuA1 before this coalescence being oblique; MA and MP diverging distally to the separation of CuA1 from M; MA coalesced with Rs for a short distance; Cu free from M basally, shortly dividing into CuA and CuP; CuA forking before mid-wing; CuA1 diverging anteriorly and coalescing with M for a short distance; CuP weak, unbranched; 1A, 2A, 3A unbranched; cross-veins more numerous than in Raphidiidae, especially in anal area. Hind wing: slightly smaller than fore wing and with narrower costal area; recurrent humeral vein absent; venation similar to that of fore wing (anal area unknown).

The family is represented by the single genus *Permoraphidia*.

Genus *Permoraphidia* Tillyard

Permoraphidia Tillyard, 1932, Amer. Journ. Sci. **23**: 6.

Fore wing: Rs with at least two forks, each having terminal branches; Rs widely separated from R1 and connected to it by several long cross-veins; a well developed cross-vein joins M (or MA) to R1 (or Rs) before the coalescence of MA and Rs, forming a conspicuous triangular or quadrilateral cell. Hind wing: similar to fore wing, except for the differences already noted.

The body structure is unknown.

Genotype: *Permoraphidia americana* Tillyard.

Permoraphidia americana Tillyard

Figure 5

Permoraphidia americana Tillyard, 1932, Amer. Journ. Sci., **23**: 8.

Fore wing: length, 9.5–10.5 mm.; width, 2.3–2.6 mm.; elongate and oval; costal margin only slightly arched, apex somewhat pointed; recurrent humeral vein extending only to about the level of separation of CuA and CuP, with about 6 veinlets between it and the anterior margin; 4–8 costal veinlets; pterostigma rather broad, of uniform density; several subcostal veinlets present, usually four in pterostigma; Rs originating at about mid-wing; the amount of coalescence between Rs and MA is about equal to the length of the free part of Rs before the coalescence; Rs forked to level of middle of pterostigma; both terminal branches of Rs forked again at margin; MA with two or three terminal branches; MP with one or two well developed terminal branches; amount of fusion between M and CuA1 variable, but it is at least equal to the interval of coalescence of Rs and MA; CuA1 forked to about half its length; CuA2 simple, unbranched; 1A close and parallel to CuP; 2A close to 1A proximally, but diverging from it distally; 3A short and close to the posterior margin; between all anal veins is a variable number of cross-veins, mostly curved or sigmoidal. Hind wing: all of the hind wing is known except the distal part of CuP and the anal veins. The largest fragment is 8 mm. long and 2.5 mm. wide; in all probability the wing was a little shorter than the fore wing, though about as broad. Costal area narrower than in fore wing; Sc terminating as in fore wing; pterostigma slender; Rs arising further proximally than in the fore wing, M forked and coalesced with CuA1 as in fore wing.

Holotype: No. 1522ab, Peabody Museum, Yale University.

In the Harvard collection there are six specimens of this insect from the Elmo limestone, three from each layer: no. 4581, a complete fore wing, without distortion and very well preserved, except for the cross-veins; no. 4582ab, distal third of a fore wing, well preserved; no. 4584ab and no. 4585ab, fore

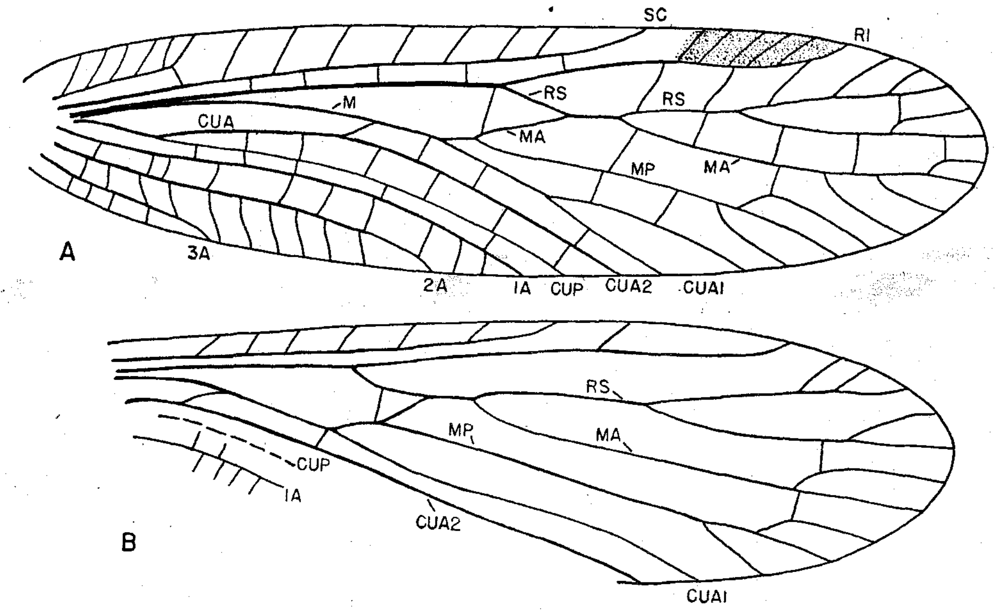

FIGURE 5. *Permoraphidia americana* Till. A, fore wing; drawing based mainly on specimens no. 4581 and 4584, Mus. Comp. Zool. B, hind wing; drawing based on specimens no. 4586 and 4583, Mus. Comp. Zool. M, common stem of MA and MP; other lettering as in figure 1.

wings, incomplete but well preserved; no. 4586ab, a hind wing, fairly well preserved; 4583ab, distal third of a hind wing. In the Sellards collection there is one nearly complete fore wing (no. 113).

The drawing of the fore wing in figure 5 is based mainly on specimen no. 4581, with the addition of some cross-veins shown better in specimen no. 4584. It should be noted that Tillyard's figure of the fore wing of *americana* (1932, p. 6) is incorrect in several details, such as the structure of the "recurrent humeral vein" (termed the costa by Tillyard) and the proximal part of the posterior wing margin. I have identified two of the fossils (nos. 4586, 4583) as hind wings of this species solely on the basis of their venation, no complete specimens of *americana* having been found. The wings mentioned have a venation identical with that of the type of *americana*, except for differences which in general occur between the fore and hind wings of existing Raphidiodea.

The wings of *americana* were apparently very delicate. This is indicated by the fact that all but one of the eight wings of this insect which have been collected are folded or torn. It is most interesting to find this true of *Permoraphidia*, since the wings of the existing Raphidiidae are also fragile. Apparently, however, the Permoraphidiid wings were not glassy, as in the Recent members of the order. Such a glassy texture is clearly preserved in the fossils of the Elmo limestone, as in the Megasecoptera and Odonata; but is not even suggested in the specimens of Permoraphidia. Macrotrichia, which are well developed in Recent Raphidiodea, are not preserved in any of the specimens of *americana*.

Permoraphidia grandis, n. sp.

Figure 6

Fore wing: length of the preserved part of wing, 15 mm.; estimated length of entire wing, 17 mm.; width of preserved part of wing, 3 mm.; estimated width of entire wing, 4 mm. Costal space much broader basally than in *americana;* recurrent humeral vein also longer than in *americana*, with about ten veinlets leading from it to the costal margin; pterostigma slender, divided into two parts, the anterior part being thicker than the posterior part; Rs forked as in *americana;* MA coalesced with Rs with a short distance; MP and CuA as in *americana;* CuP and anal veins unknown.

Holotype: no. 4589, Museum of Comparative Zoology; collected in Elmo limestone (upper layer) at Elmo, Kansas (F. M. Carpenter).

This insect was obviously a close relative of *americana*, and I have assigned it to the same genus, even though the structure of the hind wings is unknown. It had almost twice the wing expanse of *americana*, and the fore wing was probably much broader than that of the genotype. The most peculiar feature of *grandis* is the pterostigma, the anterior part of which is thick and swollen, whereas

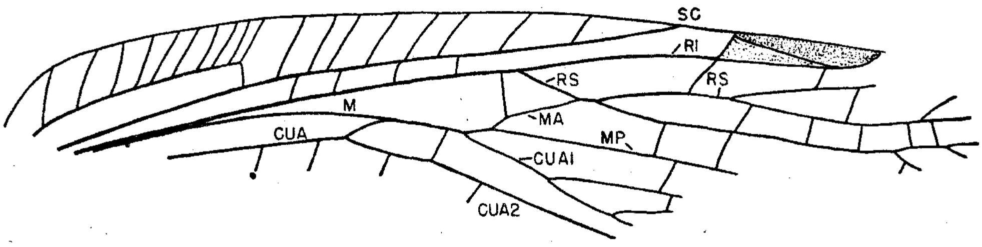

FIGURE 6. *Permoraphidia grandis*, n. sp. Fore wing; drawing based on holotype. Lettering as in figure 5.

the rest, though pigmented, is membraneous, resembling the entire pterostigma of *americana*.

THE AFFINITIES OF THE PERMORAPHIDIIDAE.

Unlike the Mesozoic and Tertiary genera of Raphidiodea,[4] *Permoraphidia* is decidedly generalized in comparison with the Recent members of the group, and it has a significant bearing on the problem of the interpretation of their venational homologies. Martynov suggested over ten years ago (1925) that the anterior media, as well as the posterior media, was present in the existing Raphidiodea. The vein which had previously been determined as the most proximal branch of Rs he believed to be the anterior media, which was coalesced proximally with the stem of Rs. The evidence for this was derived mainly from analogies with the wings of Neuroptera (Planipennia). The venation of *Permoraphidia*, as Tillyard has shown, fully substantiates Martynov's conclusions. In the fore wing of *Permoraphidia* the actual origin of MA and its coalescence with Rs are very clear; so, too, are the origin and coalescence of CuA1 with M. In the hind wing of *Permoraphidia*, which was not known to Tillyard, the structure of MA and CuA1 is practically identical with that of the corresponding veins in the fore wing, except that they originate somewhat nearer the base of the wing, as in the hind wings of existing Raphidiodea. The distinct coalescence of CuA1 with M in the hind wing of *Permoraphidia* is of much interest, for the possibility of such a coalescence in the hind wings of existing Raphidiodea has not previously been suggested. I am now convinced that this coalescence (CuA1 and M) does take place in the Raphidiidae and Inocelliidae. An examination of the hind wing of any of the existing genera of snake-flies shows that the vein which I have previously regarded (Carpenter, 1936, fig. 1) as the posterior branch of MP is strongly convex, as CuA1 should be. A comparison of such a wing (Fig. 7) with the hind wing of *Permoraphidia* indicates that the obscurity of the coalescence in the former has resulted from the distal migration of the point of separation of CuA1 from M. This migration has progressed so far that CuA1 in existing Raphidiodea is now fused proximally with the base of MP. The Jurassic snake-flies (Mesoraphidiidae), it must be admitted, are fully as specialized as the Recent species in this respect, and do not show an intermediate condition, as might be expected.

Although *Permoraphidia* thus aids in the determination of the venational homologies in Recent Raphidiodea, I do not believe that this genus, or the family which it represents, is ancestral to the Mesoraphidiidae, Raphidiidae or Inocellidae. The chief difficulty in the way of such a relationship is the presence of the strong, recurrent vein in the humeral angle of the fore wing. This vein was identified by Tillyard as "the last vestiges of a truly archaic costal vein homologous with that in Permian

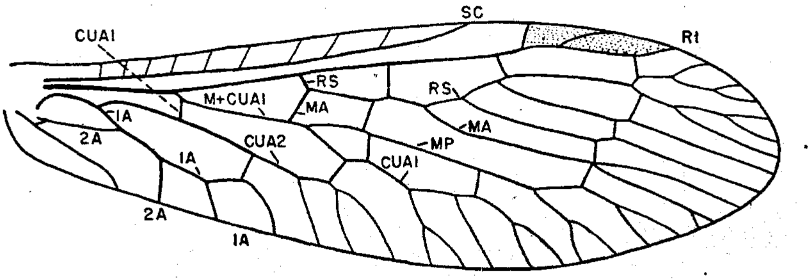

FIGURE 7. Hind wing of *Agulla assimilis* (Alb.) (Recent). Lettering as in figure 5.

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[4] See Martynov, 1925; Carpenter, 1936.

Plectoptera." Interpreted in this way, it would be a generalized structure, lost in the subsequent evolution of the order. In my opinion, however, it is more likely the homologue of the "recurrent humeral vein" which is found in many Neuroptera, and which is formed, apparently, by the alignment of several costal veinlets. The absence of the recurrent vein in the hind wing of *Permoraphidia*, as in the Neuroptera, supports this view, rather than Tillyard's; for the submarginal costa (costal brace) of the Permian Plectoptera is as well developed in the hind wing as in the fore. Tillyard's reference to the condition in *Oliarces* is rather puzzling. I have examined the unique specimen by which this genus is known in the Museum of Comparative Zoology, and find that the recurrent vein there is like that of other Planipennia—apparently formed of aligned veinlets. For these reasons, I consider the recurrent humeral vein in the fore wing of *Permoraphida* to be a specialized, rather than a generalized characteristic.

Order CALONEURODEA

This order was established by Martynov in 1938 (1938a) for a series of fossils formerly placed in the Protorthoptera. The following families were included by him in the new order:

CARBONIFEROUS

Caloneuridae (France; Pennsylvania)
Protokollaridae (France)
Stenaroceridae (France)
? Emphylopteridae (France)

PERMIAN

Euthygrammidae (Russia)
Permobiellidae (Kansas)
Synomaloptilidae (Russia)

In my opinion, the Protokollaridae and Stenaroceridae, both of which were based on single genera, do not belong to the Caloneurodea.[5] The family Emphylopteridae, which was doubtfully included by Martynov in the Caloneurodea, I also exclude from this order. However, in this paper I am erecting three additional families of Caloneurodea: Paleuthygrammidae, Pleisiogrammidae, and Anomalogrammidae. These are established chiefly for species in the Elmo limestone. Although Tillyard described one species of Caloneurodea in the Yale Collection from this formation, he placed it in the Neuroptera. The present paper is therefore the first account of the Caloneurodea as such in the Elmo beds, and it is based upon the specimens contained in both the Yale and Harvard collections.

The characteristics of the order Caloneurodea have been thoroughly discussed by Martynov in a posthumous publication (1938b), but since his paper was printed in Russian, I include here a summary of these characteristics, including several details furnished by the new fossils.

The body structure of the Caloneurodea is only partially known.[6] The head was of moderate size and apparently hypognathous; the antennae were very long and slender; the first antennal segment was large and swollen; the structure of the eyes is unknown. The prothorax was about as long as wide. The abdomen was of moderate size, rather slender, and terminated in a pair of short cerci. The legs were slender, often tenuous; the posterior pair were longer than the others but were not modified for jumping. The tarsal segmentation is unknown.

The fore wings of the Caloneurodea were at least moderately slender and were often very elongate. The hind wings were similar to the fore wings in shape and venation; they were a little broader than the fore wings, but did not possess an enlarged anal area.[7] The fundamental pattern of the venation seems to have been much the same in all families, so far as known. At first glance this pattern seems very simple and generalized, with MA, MP, CuA, and CuP present. However, a more detailed study of the veins, especially with reference to their convexity or concavity, reveals a most perplexing condition, and, in my opinion, a highly specialized one. The identity of the subcosta, radius, and radial sector is obvious. Sc is long, extending at least to mid-wing and often to the apex; R1 is unbranched and terminates about at the apex; Rs usually originates somewhat proximally of the mid-wing and gives rise to a variable number of branches, from two to many. The homology of the next three longitudinal veins is more difficult to determine. The convexity or concavity of all veins, except the anals, is very strong; this is true of Sc and Rs, which are concave, and of R1, which is convex. Below Rs is a forked vein (labeled 1 in figure 8) which arises directly from the vein below it; this vein (1) and both of its branches are strongly concave, like Rs. The vein from which it arises (labeled 2 in figure 8) is very strongly convex; paralleling this vein and situated just below it is a concave vein (3 in figure 8). In his 1906 treatise on fossil insects Handlirsch figured the wing of the Carboniferous *Caloneura* and identified vein 1 (figure 8) as the media, and veins 2 and 3 as branches of Cu. This is the obvious interpretation of the veins, made without regard to their convexity or concavity. Lameere, in 1917, identified vein 1 of *Caloneura* as the media, vein 2 as CuA (+) and vein 3 as CuP (−). This interpretation agrees with the convexity and concavity of the branches of Cu. Martynov (1928) in his description of *Euthygramma*, and Tillyard (1937) in his account of *Permobiella* (which he placed in the Neuroptera) interpreted the venation of their respective genera in like manner. In 1938, however, Martynov, after a survey of the Order Caloneurodea, proposed a new interpretation, designating vein 1 as MA, vein 2 as MP, vein 3 as CuA, and the concave vein below the last as CuP.[8] As Martynov has noted, according to this interpretation, MA is concave, MP is convex, CuA concave, and CuP convex. These are exactly the reverse positions of the homologous veins in other insects. Such an interpretation can therefore be valid only if we assume that these particular veins have changed through evolutionary processes from a concave position to a convex one or vice versa. I do not believe such changes have ever been demonstrated in the insects (except perhaps in the case of elytra, where the thickening of the wing introduces another factor); and until that has been done, I consider Martynov's interpretation untenable. The following identification of the veins is used here: vein 1 is MP (−), MA having been lost; vein 2 is CuA (+), being coalesced proximally with MA; vein 3 is CuP (−). I must admit, however, that one peculiarity of the venation of the Caloneurodea leads me to have a suspicion of doubt about even this interpretation. The vein here designated as CuP, although close to CuA for most of its length, diverges away from it proximally and coalesces with the base of the vein below (here identified as 1A), which shows neither convexity nor concavity. This basal coalescence is apparently a characteristic of the order, for it occurs in all genera, Carboniferous as well as Permian, which have been found. The difficulty of the present interpretation is that CuA and CuP do not originate from a common stem; instead, CuP arises from the base of 1A. Such a common origin of 1A and CuP does occur, of course, among living insects, but its presence in the Caloneurodea adds another specialization to a wing which at first glance seems to be generalized.

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[5] The reasons for this conviction will be discussed in my revisional study of the insects of the Commentry shales, now in preparation.

[6] Martynov has published a good restoration of one of the species from the Permian of Russia, though not all the details shown in his figure are actually known (1938b, p. 126, fig. 63).

[7] Zeuner has stated (1938, p. 69) that the hind wings of the Caloneuridae possessed an anal fan. I do not know any basis for this assertion. None of the specimens which I have seen, including those from Commentry, show this anal fan and so far as I am aware no other mention of it occurs in the literature on the Caloneurodea.

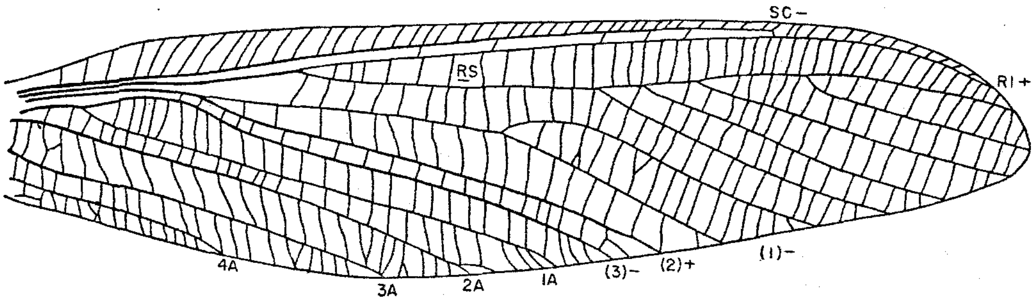

FIGURE 8. *Caloneura dawsoni* Brongn. (Carboniferous of Commentry, France). Original drawing, based on types in the Muséum d'Histoire Naturelle, Paris. Sc, subcosta; R1, radius; Rs, radial sector; MA, anterior media; MP, posterior media; CuA, anterior cubitus; CuP, posterior cubitus; 1A, 2A, etc., anal veins; +, convex veins; −, concave veins. For explanation of (1), (2), (3), see text.

The anal veins of the Caloneurodea vary from five in the Carboniferous species to two in some of the Permian members. One of the most striking features of the wings of these insects is the convexity of the numerous cross-veins. In all known species the cross-veins are very heavy and are often stronger than the longitudinal veins. This peculiarity and the proximity of CuA and CuP (or CuP and 1A in

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[8] Unfortunately Martynov based this interpretation on the structure of the genus *Euthygramma*, which differs radically from all other Caloneurodea in having vein 2 remote from vein 3, and in having the latter very close to the concave vein below it. See Martynov, 1938a, figure 1a, p. 71.

Euthygramma) are the two chief characteristics by which the order may be recognized.

The classification of the species of Caloneurodea into families is at present very uncertain. Since we know but few species within the order, any classification is likely to be more convenient than natural. Hence, whatever family classification is now adopted will undoubtedly need to be modified as additional species become known. Inasmuch as the new genera from the Elmo limestone do not fit satisfactorily into families already established, I have been compelled to erect three new families for them. A survey of all described genera of the order, both Carboniferous and Permian, reveals two striking facts: 1) all genera are very similar in general pattern of the venation, and 2) all show intermediate conditions of their generic characteristics. The pronounced upward arching of MA1 + 2 in the new genus *Apsidoneura* is illustrative of the latter. This arching is present to a slight extent in several of the Permian genera and especially in the Carboniferous *Homaloneura*. Another illustration is furnished by the branches of Rs. These range from six or seven in the Caloneuridae to none in *Euthygramma;* but the number of branches varies specifically to such an extent as to render it useless for generic diagnosis. There are many other venational characteristics which show the same tendency. So far I have found it virtually impossible to erect the framework of a satisfactory classification of these peculiar insects.

The affinities of the Caloneurodea are not very clear. They are undoubtedly a part of the Orthopteroid complex and may be, as Martynov believed, an offshoot of the early Protorthoptera. Zeuner has suggested (1939) that the Caloneuridae might be related to the ancestors of the Acridioidea, and also has stated that the primitive acridioid family Locustopsidae could easily be derived from the Caloneuridae. I find it difficult to conceive of such a relationship on the basis of our present knowledge. Whether or not the Caloneurodea require permanent separation from the Protorthoptera as a distinct order can only be decided after many more species and anatomical details are known than now.

Paleuthygrammidae, new family

Fore wing: long and slender; costal area of moderate width; Sc long, terminating not far from the apex of wing; Rs arising near the middle of the wing, with two or rarely three branches; MP arising well before and forking beyond the origin of Rs; CuA and CuP straight and very close together, terminating in the distal fourth or fifth of the wing; 3 anal veins; 1A and 2A close together proximally, diverging distally; 3A sigmoidally curved, terminating at about mid-wing; cross-veins numerous, usually straight, sometimes sigmoidal. The fore wing (and perhaps the hind also) has a peculiar, granular texture. This is indicated in only one, splendidly preserved wing (no. 15572ab), but the absence of the granular structure in other fossils is almost certainly a matter of poorer preservation of the insects. The granulation is apparently caused by numerous minute dark spots, resembling the bases of microtrichia. No macrotrichia or microtrichia are visible on any of the wings.

Hind wing: only a little shorter than the fore wing; the costal space is somewhat narrower than that of the fore wing, and hind margin is more curved proximally.

The body structure is very little known. The head was of moderate size, the antennae and legs elongate, as in other Caloneurodea.

This family is erected for two new genera and also for several genera which Martynov placed in the Euthygrammidae. The genus *Euthygramma*, on which the latter family was based (Martynov, 1928), is so different from the other genera included there that I believe it requires a separate family. These differences are chiefly the unbranched Rs and the proximity of CuP and 1A, instead of CuA and CuP, as in other genera.

The family Paleuthygrammidae, which is known from the Permian of Russia and Kansas, includes the following genera: *Paleuthygramma* Mart., *Vilviopsis* Mart., *Vilvia* Zal., *Pseudogramma*, n. gen., and *Apsidoneura*, n. gen. *Vilvia* is readily distinguished by the density of the cross-veins. *Paleuthygramma* may be defined at present as including those species with a forked Rs. *Vilviopsis* has a radial sector with three branches, but I suspect that additional specimens of *Paleuthygramma* will show that generic separation because of the difference of one branch of Rs will not hold. The new genus **Pseudogramma** is here erected by me for *aberrans* Martynov, which was placed by its author in *Euthygramma*. Martynov considered it probable that MP in this species was coalesced with Rs. In view of the structure in additional Caloneuridae, however, I believe that such a condition is most improbable and that MP is really unbranched, as in one of the Kansas species of Caloneurodea. This, of course, implies that the straight and nearly contiguous veins in the wing are CuA and CuP. However, in either case, i. e., whether MP is a simple vein or is coalesced with Rs, a distinct genus appears necessary for this species.

Two genera of this family, *Paleuthygramma* and *Apsidoneura*, n. gen., occur in the Elmo limestone.

Genus *Paleuthygramma* Mart.

Paleuthygramma Martynov, 1930, Ann. Soc. Pal. de Russie, **8**: 42; 1938, Trav. de l'Inst. Paléont., **7**: 126.

Fore wing: Sc terminating at about the level of the fork of Rs, usually a little proximad to it; Rs arising at mid-wing, or slightly before it and forked dichotomously near the apex of the wing; MP deeply forked, almost to half its length; 2A and 3A sinuously curved. The cross-veins are numerous, as characteristic of the family; most of them are straight, but those in the distal part of the wing tend to be sigmoidal. Hind wing: similar to the fore wing, but with a narrower and straighter costal margin; apex slightly more rounded than that of fore wing; 3A more curved than in fore wing.

This genus was established by Martynov for the single species *tenuicornis* Mart., from the Permian of Russia. The unique type consisted of a whole specimen, which showed the general body structure and most of the venation of one wing. A closely related species is represented in the Yale and Harvard collections from the Elmo limestone. In fact, its venation is so close to that of *tenuicornis* that I have found it impossible to separate the two species generically, in spite of the great difference in their geographic range.

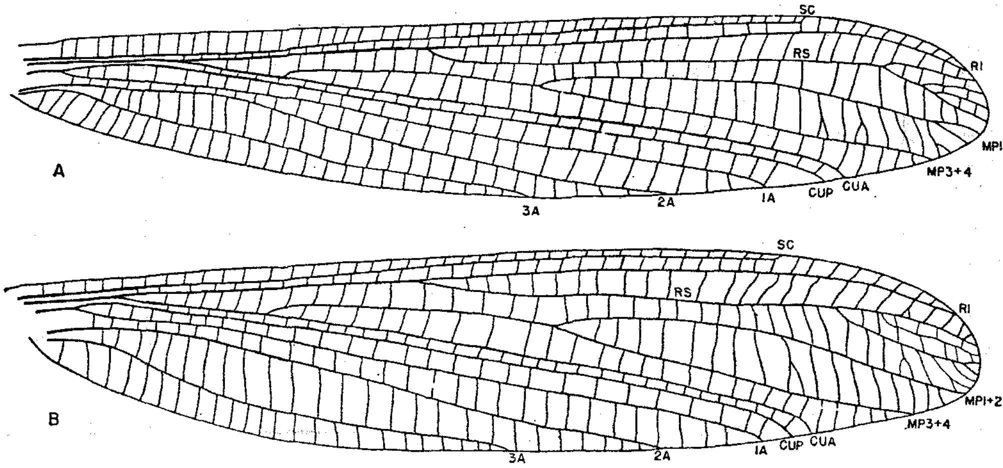

FIGURE 9. *Paleuthygramma acuta*, n. sp. A, fore wing; drawing based chiefly on holotype and specimen no. 4563, Mus. Comp. Zool. B, hind wing; drawing based chiefly on holotype and specimen no. 4554, Mus. Comp. Zool. Lettering as in figure 8.

Paleuthygramma acuta, n. sp.

Figure 9

Fore wing: length (holotype), 18 mm.; width, 3 mm.; costal margin slightly narrowed at very base; Sc terminating before the level of the forking of Rs; Rs with a conspicuous though shallow fork; sometimes the alignment of cross-veins within the latter fork gives the impression of a weak intercalated vein between its branched; point of separation of MP from Cu variable, but always well proximal to the origin of Rs; anterior branch of MP slightly curved in its distal half; 1A close to 2A proximally; 2A slightly curved sigmoidally; 3A arched near the base of the wing. Hind wing: length (holotype), 17 mm.; width, 4 mm.; similar to the fore wing, except for the differences noted under the genus.

Very little is known of the body structure of this insect. The abdomen, preserved in three specimens (Peabody Museum, 15655; M. C. Z. 4587, 4547) is 9 mm. long and 2.5 mm. wide. One specimen (M. C. Z. 4547) shows several terminal abdominal appendages. Two of these (3 mm. long) are segmented and are probably cerci; the others, included between the cerci, are incomplete and I have not been able to determine their precise form. The prothorax (M. C. Z. 4587) is 2 mm. long and 2 mm. wide. The legs were obviously long and slender; the middle femur is 5 mm. long and the tibia is at least 4 mm. long, since that much of a tibia is preserved without the distal end being evident. One hind tibia is preserved (M. C. Z. 4545); this is 9 mm. long. The tarsal segmentation is unfortunately not known. The body structure of *acuta*, as far as known, was apparently much like that shown in Martynov's restoration of *Paleuthygramma tenuicornis* (1938, fig. 63), except that the legs of *acuta* were probably longer.

Holotype: Museum of Comparative Zoology, No. 4587ab, collected in the lower layer of the limestone at Elmo, 1935 (F. M. Carpenter). This consists of a partially complete insect; three wings extend along the abdomen, and one fore wing, preserved only to about the middle, lies at right angles to the body. This specimen therefore shows part of a fore wing and at least one complete hind wing, though the proximal part of the latter is obscured by the abdomen.

Paratypes as follows: Two in the Peabody Museum, Yale University, collected in the Elmo beds by C. O. Dunbar: No. 15572ab, a fore wing, very well preserved, but with the posterior part, below 1A, broken away; this specimen shows clearly the texture of the wing. No. 15571, a nearly complete fore wing, with apex missing.

Nine in the Museum of Comparative Zoology; all collected at Elmo, 1927–1935 (F. M. Carpenter): No. 4563ab, basal third of fore wings, excellent preservation (upper layer of limestone); No. 4554, a nearly complete hind wing, apex missing (lower layer); No. 4566, basal half of fore wing (upper layer); No. 4558ab, basal third of fore wing, excellent preservation (upper layer); No. 4547ab, parts of wings and body, especially the abdomen (lower layer); No. 4560ab, distal third of wing, excellent preservation (lower layer); No. 4556, nearly complete fore wing (lower layer); No. 4558ab, nearly complete fore wing (upper layer).

In addition to these twelve type specimens, there are four other specimens in the Yale collection (Nos. 15661, 15655b, 15657ab, 15656a) and twenty in the Museum of Comparative Zoology. These make a total of thirty-five specimens in both collections.

Since none of these shows either a fore or hind wing entirely complete, the drawings in figure 9 have been based on several specimens. A comparison of figure 9 with that of *Paleuthygramma tenuicornis* Mart., the genotype, reveals the close similarity of the species. Probably a greater difference exists in the anal area, which is not preserved in the genotype; but I do not believe that this will be enough to require generic separation of the two species.

The correlation of the fore and hind wings of this insect is made possible chiefly by the holotype, which includes parts of all four wings. The differences are indeed slight, as indicated above, and are mainly confined to wing shape. This difference in shape between the fore and hind wings is almost certainly a generic characteristic.

The individual fossils show slight variation in venation. The place of origin of MP is subject to slight variation as is also the depth of the forks of Rs and MP; but the individual differences are not comparable in extent to those in the Protoperlaria and most other groups of Permian insects (see Carpenter, 1935).

Apsidoneura, new genus

Wings subpetiolate and slender, though not so elongate as in *Paleuthygramma;* Sc terminating almost at very apex of wing; Rs arising somewhat nearer the base than the apex, with 2–3 branches; MP originating at point of separation of Cu from R and M, and forking well beyond mid-wing; anterior branch of MP strongly arched towards Rs; CuA and CuP straight and very close together; CuP and 1A coalesced basally; 3 anal veins present; 1A remote from CuP; 3A somewhat shorter than in *Pseudogramma* and *Paleuthygramma.*

This genus is known only from two isolated wings; both are probably fore wings.

Apsidoneura flexa, n. sp.

Figure 10; plate 1, fig. 2

Length of wing (holotype), 30 mm.; maximum width, 6.5 mm. Costal margin straight, apex rounded, posterior margin convex; proximal third of wing more slender than rest; costal space much broadened in proximal half, but narrowed distally; R1 terminating at apex of wing; Rs curved anteriorly towards R1 opposite the upward curve in anterior branch of MP; MP straight from its origin to its fork; anterior branch of MP arching abruptly towards Rs for a short distance, them curving posteriorly; CuA and CuP are weak and twigged at their terminations; 1A terminating about at level of fork of MP; 2A terminating just beyond level of origin of Rs; 3A well developed but close to wing margin. Cross-veins numerous, convex, the longer ones sigmoidally curved. In the region of the branches of Rs some cross-veins have aligned to form short intercalated veins.

Holotype: No. 4572ab, Museum of Comparative Zoology, collected in the upper layer of the Elmo limestone, 1932 (F. M. Carpenter). This is a splendidly preserved specimen.

Paratype: No. 4551, Museum of Comparative Zoology, collected in the lower layer of limestone at

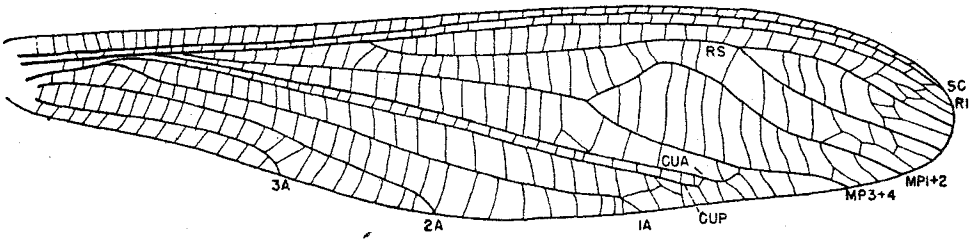

FIGURE 10. *Apsidoneura flexa*, n. sp. Drawing of holotype. Lettering as in figure 8.

Elmo (F. M. Carpenter). This is an incomplete wing, lacking that part of the wing which is proximal to the separation of MP from R + M. The wing is 23 mm. long as preserved and 6.5 mm. wide. The venation is identical with that of the holotype, except that Rs is 3-branched, R2 + 3 forking near the apex.

This species unquestionably requires generic separation from the other members of the family. It is distinctive in possessing the long Sc, arched MP1 + 2 and the relatively short 3A. The form of MP is most peculiar, but it is interesting to note that a tendency for curvature of this vein occurs in *Pseudogramma*. An even more pronounced approach to the condition of MP in *Apsidoneura* is found in the Carboniferous *Homaloneura similis* Meunier, which resembles *flexa* in several other respects, also.

Pleisiogrammidae, new family.

Wings moderately slender; costal area of moderate width; Sc long, extending beyond mid-wing; Rs arising well before mid-wing, with 3 or 4 branches; MP arising before origin of Rs, not strongly arched towards Rs; CuA and CuP straight and close together, terminating just distad to mid-wing, much shorter than in Paleuthygrammidae; CuP and 1A coalesced basally; only two anal veins well developed, 3A reduced to a small vestige at base of wing; cross-veins numerous, but less so than in Paleuthygrammidae.

This family is established for two new species, both represented by isolated wings. Their venation is so different from that of other Caloneurodea that I have been unable to allocate them to any described family. They apparently represent a specialized branch of the order, characterized by almost complete loss of the third anal vein. I have tentatively placed both species in the single genus *Pleisiogramma*, but it may eventually be necessary to separate them at least generically. However, since we know nothing of the differences between their fore and hind wings, I have considered it advisable to group them into one genus until this important aspect of their structure is known.

Pleisiogramma, new genus

Wings subpetiolate; Sc extending at least as far as the fork of Rs; MP either deeply forked or simple; end of CuA and CuP weak distally and twigged; 1A close to 2A proximally, more remote distally; 2A ending at about mid-wing or just before it.

Genotype: *Pleisiogramma medialis*, n. sp.

Pleisiogramma medialis, n. sp.

Figure 11

Length of wing, 17 mm.; width, 4.5 mm.; costal margin straight or nearly so, with a slight curve basally; apex rounded; posterior margin strongly curved; Sc extending almost to very apex of wing; Rs arising about one-fourth of wing length from base, and forking into R2 + 3 and R4 + 5 just beyond mid-wing; R2 + 3 forked soon after its origin, and R2 also deeply forked; R3 and R4 + 5 are slightly curved distally towards R2; MP arising slightly before the origin of Rs, unbranched; 2A

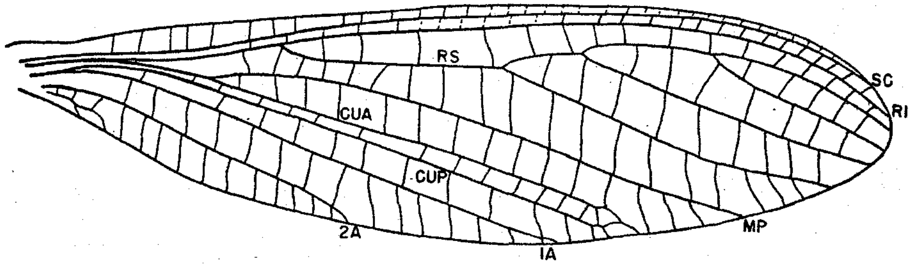

FIGURE 11. *Pleisiogramma medialis*, n. sp. Drawing of holotype. Lettering as in figure 8.

terminating well before mid-wing; 3A very short and close to posterior margin; cross-veins numerous, mostly sigmoidal.

Holotype: No. 4540ab, Museum of Comparative Zoology, in the upper layer of the Elmo limestone (F. M. Carpenter). The specimen consists of a very well preserved wing, which might be either a fore or hind wing.

This species differs from all the other Caloneurodea, except *Pseudogramma aberrans* Mart., in having an unbranched MA. The possibility that MA actually is forked and that its anterior branch is coalesced proximally with Rs, does not seem to me at all likely. If this were the case, a portion of MP leading to Rs should be visible. Since MP and Rs are strongly concave, this piece of MP would of course also be concave; but all of the cross-veins between MP and Rs are strongly convex.

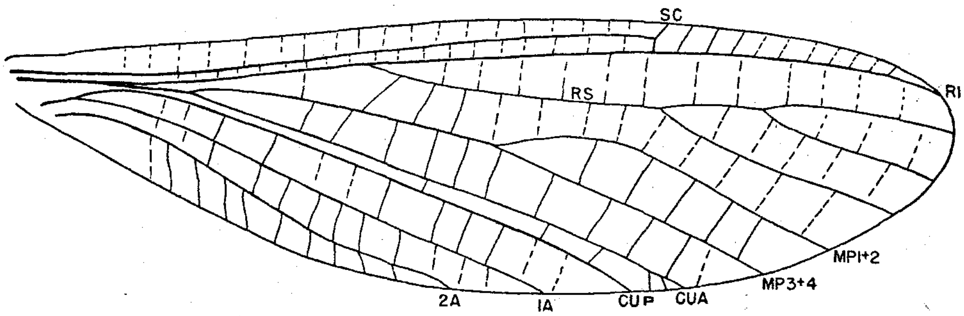

FIGURE 12. *Pleisiogramma reducta*, n. sp. Drawing of holotype. Lettering as in figure 8.

Pleisiogramma reducta, n. sp.

Figure 12

Length of wing, 15 mm.; width, 4 mm. The wing shape is essentially like that of *medialis*. Costal area a little broader than that of the latter; Sc terminating at about a third the wing-length from the base, directly above the first fork of Rs; Rs arising nearer the middle of the wing than in *medialis* and giving rise to 3 branches, R4 + 5 and R2 and R3; MP arising much nearer the base than the point of origin of Rs and forked at about mid-wing; its posterior branch continues the line formed by the stem of MP, and its anterior branch is directed gradually anteriorly; CuP and 1A close together at base, remote distally; 2A is somewhat longer than in *medialis;* 3A is not preserved, but if present it is obviously very short.

Holotype: No. 4553ab, Museum of Comparative Zoology, collected in the lower layer of the Elmo limestone, 1927 (F. M. Carpenter). This specimen consists of a fairly well preserved wing, which lacks only a small strip along the apical and posterior margin. The cross-veins are clearly preserved in the proximal part of the wing, but are obscure distally.

This species resembles the foregoing in the wing shape and the reduction of the third anal vein. It differs from *medialis*, however, in a number of respects, such as the shorter Sc and forked media; these differences and others may eventually require the erection of a distinct genus for *reducta*. Until a complete specimen of either species (showing both fore and hind wings) has been found, and proven the contrary, the possibility remains that *medialis* and *reducta* are based upon fore and hind wings of one species. However, in view of the nature of the differences between them, the chances of this seem very remote.

Anomalogrammidae, new family

Wings slender, but not subpetiolate; costal area of moderate width; Sc relatively short, terminating at about mid-wing; space between R1 and costal margin, beyond end of Sc, very broad; Rs arising well before mid-wing, forked; MP arising nearly at point of separation of Cu from R + M, deeply forked; CuA not so close to CuP as in Paleuthygrammidae; CuP twigged distally; CuP and 1A coalesced basally; only two anal veins are present in the fossil on which the family is based, but a third anal vein might have been present in the original wing, since this part of the wing is poorly preserved. Cross-veins convex but relatively few in number.

This family is erected for a species having a very peculiar venation. Sc is shorter than in other members of the order, R1 diverges away from the costal margin beyond the end of Sc, and the cross-veins are not at all numerous (i. e., for a Caloneurodean). Because of these characteristics and several others not occurring elsewhere in the Caloneurodea, I have considered a distinct family necessary for this insect. The family is apparently related to Paleuthygrammidae, but includes more highly specialized species with a greater reduction of the venation.

Anomalogramma, new genus

Wings with the proximal half much more slender than the distal half; Sc terminating at mid-wing; MP forked just below the end of Sc, its anterior branch arched slightly towards Rs at first, then curved away; CuA close to CuP proximally, but diverging from it distally; CuA and CuP weak and twigged distally.

Genotype: *Anomalogramma parva*, n. sp.

Anomalogramma parva, n. sp.

Figure 13

Wing: length, 9 mm.; width, 2 mm.; costal margin straight, apex rounded, posterior margin only slightly curved; Sc close to R proximally but diverging abruptly towards costal margin soon after the origin of Rs; Rs forked to about a third of its length; Rs arched towards MP just beyond mid-wing, then curved upwards towards R just before forking; CuA slightly zigzagged distally, CuP more so, extending apically towards CuA along hind margin of wing; 1A nearly straight. The longer cross-veins are sigmoidally curved.

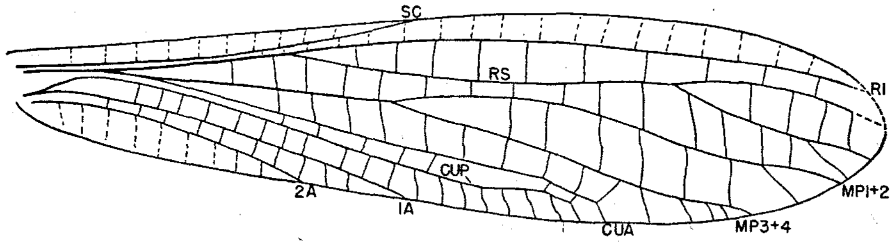

FIGURE 13. *Anomalogramma parva*, n. sp. Drawing of holotype. Lettering as in figure 8.

Holotype: No. 4561, Museum of Comparative Zoology; collected in upper layer of Elmo limestone, 1935 (F. M. Carpenter). This specimen consists of a nearly complete wing, lacking only a very small piece near the apex. The preservation is good for such a small wing, though many of the cross-veins are not discernible. Whether the specimen is a fore or hind wing cannot be determined at present.

This insect is the smallest member of the Caloneurodea so far known. The venation as a whole is fundamentally like that of the Paleuthygrammidae but differs in the structure of the individual veins, as indicated under the genus.

Family PERMOBIELLIDAE

Wings moderately slender, not subpetiolate; costal area of moderate width; Sc terminating not far from mid-wing. R1 longer than in Paleuthygrammidae, extending to the very apex of the wing; Rs arising before mid-wing, with 3 branches; MP arising at point of separation of Cu from R, deeply forked; CuA and CuP close together proximally, but diverging distally; 1A remote from CuP; at least 2 anal veins present.

This family was placed by Tillyard in the order Neuroptera. He apparently overlooked the very close similarity between its venation and that of the Caloneuridae or Martynov's family Euthygrammidae, for neither of these is mentioned in his discussion of the fossil. Martynov has already shown that the true position of the Permobiellidae is with the Caloneurodea (1938a, 1938b). The Permobiellid venation differs from that of all other families in the order by the pronounced divergence of CuA and CuP distally as well as by the extraordinary convexity of the cross-veins, and the length of R1.

Genus *Permobiella* Till.

Permobiella Till., 1937, Amer. Journ. Sci., **33**: 101; Martynov, 1938, **7**: 80

Wings with the proximal half much narrower than the distal half; Sc terminating very slightly beyond mid-wing; MP forked to about mid-wing, its anterior branch very slightly arched towards Rs; CuA slightly zigzagged distally and twigged; CuP parallel to CuA proximally, but curved away distally. Cross-veins very strongly convex, more so than in any other genus of Caloneurodea.

Genotype: *Permobiella perspicua* Till.

Permobiella perspicua Till.

Figure 14

Permobiella perspicua Till., 1937, Amer. Journ. Sci., **33**: 102

Wing: length of wing fragment (holotype), 11 mm.; width, 3.6 mm.; the basal part of the wing, proximal to the origin of MP, is missing; the complete wing was probably about 14 mm. long. Costal margin slightly arched, apex probably pointed (not rounded as drawn by Tillyard); posterior border nearly straight; R4 + 5 is about one-half as long as the entire Rs; R2 and R3 are nearly as long as R4 + 5; between the branches of Rs, the cross-veins form short intercalated veins; nearly all cross-veins in the wing are sigmoidally curved and are dark brown.

Holotype: No. 15593, Peabody Museum. This consists of a nearly complete wing, lacking the proximal fifth.

In the Museum of Comparative Zoology there is one specimen (no. 4552ab, lower layer of the Elmo limestone); this consists of the distal half of a wing.

Tillyard's figure of *perspicua* is incorrect in several respects. The apex of the wing is partially obscured by a plant fragment in the holotype, and the part of the apex that is preserved is obviously distorted. The apex is perfectly preserved in the Harvard specimen, however, and is clearly much more pointed than it is represented in Tillyard's drawing. R1 is not strongly curved distally, as he drew it, but terminates before the apex of the wing. He was also under the erroneous impression that the holotype was practically complete and he indicated the base of the wing just beyond the limits of the fossil. In view of the structure of other Caloneurodean wings, however, I believe this wing was much longer than he supposed.

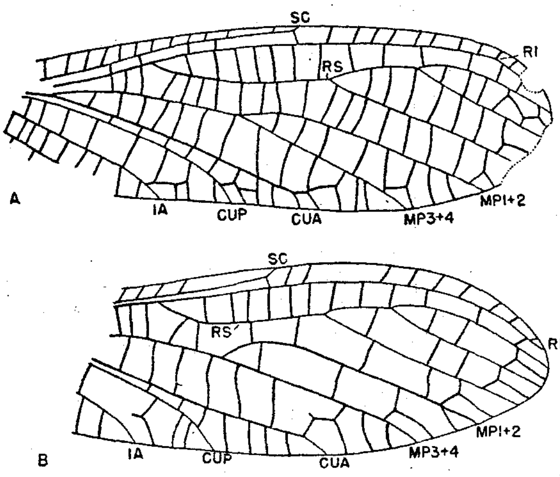

Figure 14. *Permobiella perspicua* Till. A, drawing of holotype; B, drawing of specimen no. 4552, Mus. Comp. Zool. Lettering as in figure 8.

Tillyard noted, and also indicated by the specific name *perspicua*, that the cross-veins of this wing were remarkably convex. Their dark brown color adds to their prominence and makes them far more conspicuous than the longitudinal veins.[9] There is a noticeable difference in the number and arrangement of the cross-veins between the holotype of *perspicua* and the specimen in the Harvard collection. This discrepancy is almost certainly due to individual variation, rather than to specific difference. The occurrence of several incomplete cross-veins in the Harvard specimens is strong support of this conclusion.

Order PROTORTHOPTERA

This order was established by Handlirsch in 1906 for a series of Carboniferous and Permian insects, presumably transitional between the Paleodictyoptera and the Orthoptera (s. l.). Since its erection, the order has become a vague assemblage of all Paleozoic insects which show traces of Orthopteroid characteristics. The taxonomic confusion of these fossils has been increased by the gradual diminution of the distinctions between the Protorthoptera and Protoblattoidea, another Paleozoic order erected by Handlirsch for species supposedly intermediate between the Blattaria and Paleodictyoptera. In recent years, an extensive series of Carboniferous and especially Permian species has been described which cannot be placed definitely in either of these orders. Many attempts have been made to divide the order into several suborders (e. g. Handlirsch, 1937), but there have always remained a great many families and genera which failed to fit into the proposed divisions. Several of the suborders thus formed have subsequently been completely removed from the Protorthoptera and set up as distinct orders (e. g. Caloneurodea), but these moves have had little effect on the extreme heterogeneity of the remaining Protorthoptera. Martynov has attempted (1938b) to obtain some homogeneity by restricting the order so as to include only the Paleozoic saltatorial Orthopteroids; the non-saltatorial forms he places in a distinct order, Paraplecoptera. Even if such a classification is assumed to have a phylogenetic basis, which seems dubious, it is obviously impractical, for the leg structure is unknown in more than four-fifths of the species which have been placed in the Protorthoptera.

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[9] This is indicated clearly in the photograph of the Harvard specimen of *P. perspicua* published in the Annals of the Carnegie Museum, 1934, vol. 22, pl. 24, fig. 2. It should be noted that as a result of an error which escaped my attention in the proof, the caption under this figure is incorrect. It should read, "A Caloneurid from the Lower Permian of Kansas, No. 4552, Museum of Comparative Zoology. Note the thickness and convexity of the cross-veins. About x5." This photograph of *perspicua* was included for comparison with *Caloneurella carbonaria*, described in the text.

In my opinion, most of the difficulties encountered in the taxonomy of the Protorthoptera have resulted from two factors. In the first place, many of the species, genera and families have been founded on small wing fragments, too incomplete to permit determination of their affinities. Such fragmentary material will have to be ignored in the formation of a taxonomic system within the order. In the second place, many of the species have been so incompletely and inaccurately described that their true affinities have not been apparent. The majority of the known Protorthoptera are from the Carboniferous and have been described by Scudder, Brongniart, Meunier and Handlirsch. The figures and descriptions of Scudder and Brongniart, though accurate and complete enough for the need of their times, do not include many details (as convexity and concavity of the veins) which are now essential; those of Meunier, as is well known, are totally unreliable; and those of Handlirsch, though better than Meunier's, are usually incomplete and very erratic.[10] The deplorable state of the literature on the Protorthoptera convinced me several years ago that a "revision" of the Carboniferous Protorthoptera, based on published figures and descriptions, would in no way ameliorate the taxonomy of these insects. For this reason I have spent a large part of the past three years in a study of the type specimens of this group of fossils, both European and North American. This task has now been completed and the drawings and descriptions are being assembled for publication. A discussion of the classification of the Protorthoptera will be included there. In the present paper and in the subsequent part in this series, I shall use the term Protorthoptera in a broad sense, and shall not attempt to anticipate the account of the Carboniferous species.

Family PROBNISIDAE

The family Probnisidae was established by Sellards (1909) in the Protorthoptera for a series of insects from the Elmo limestone having coriaceous fore wings and a Protorthopterous venation. Up to the present time the family has not been found in any other formation, so that our knowledge of it is restricted to the data provided by the Kansan fossils. Sellards described four genera and eight species in this family, but Tillyard, after a study of nearly a hundred specimens in the Yale collection, was able to demonstrate that all of these genera and species really represented a single variable species, *Probnis speciosa* Sellards.[11] From my study of the Harvard collection of Probnisids, numbering about 250 specimens, I am convinced that his synonymy is absolutely correct and also that the family Probnisidae is now known to us by only this species.

The representatives of this insect in Sellards' collection consisted of isolated fore and hind wings, but a number of the specimens which were in the Yale collection and which were described by Tillyard show parts of the body. In the Harvard collection there are many additional specimens with body structures preserved, so that we are now able to obtain an unusually good concept of the general structure of this insect. Sellards placed the Probnisidae in the Order Protorthoptera, but Tillyard concluded from his study of the Yale fossils that they were aquatic in their nymphal stages and therefore belonged to the Order Protoperlaria. I do not agree with this conclusion. I believe that the nymphs of *Probnis* were terrestrial and that the genus was closely related to the Geraridae, Ischnoneuridae and other Orthopteroids which have been placed in the Protorthoptera. The reasons for this view, as well as corrections to Tillyard's comments on my concept of the Protoperlaria, will follow the detailed description of *Probnis speciosa.*

The Probnisidae may now be characterized as follows: Insects of moderate size. Head rather small, eyes prominent and protruding laterally; antennae shorter than the thorax, robust. Thorax large and broad; prothorax short, with a small notum and a pair of moderate-sized but distinct lateral lobes, slightly overlapping the mesothorax; legs heteronomous, the prothoracic pair much shorter than the hind or middle pair; the tibia of all legs forming distally a series of conspicuous finger-like projections, these being largest on the fore legs; tarsi apparently 3-segmented. Abdomen long and robust; cerci short. Fore wing: slightly granular in appearance, coriaceous, but not elytriform; Sc terminating on the costa before the apex of wing; R1 unbranched, extending to apex; Rs arising in the proximal half of the wing, unbranched; MA and MP separating at about the level of the origin of Rs, both of these veins very variable in respect to branching; CuA and CuP separating close to the base of the wing; CuA dividing shortly after its origin into two main branches, CuA1 and CuA2;

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[10] For an example of the confusion resulting from the work of Handlirsch and Meunier, see my note on the Commentry Caloneuridae (Carpenter, 1934, p. 325–326).

[11] With the possible exception of one unrecognizable species, *Lecopterum delicosum* Sell.

CuA1 gives rise to a variable number of arched branches along the posterior margin of the wing; CuA2 usually simple; CuP unbranched, straight; 1A straight and usually simple. Hind wing: membraneous, but with a definite trace of the wrinkles which are better developed in the fore wing; costal space much narrower than in the fore wing; Sc and R1 essentially as in the fore wing; Rs arising almost at the very base of the wing, unbranched; MA and MP simple (usually) or forked; CuA separating from CuP at the very base of the wing and giving rise to several arched branches similar to those of the fore wing, except that they are usually longer; CuP straight and unbranched, terminating at the re-entrant angle of posterior margin; anal fan well developed, with at least six main veins, all of these arising from a single proximal stem.

Tillyard recognized two genera in the family in addition to *Probnis* itself: *Lecopterum* Sellards and *Telactinopteryx* Tillyard. The former genus was based upon a single fore wing (*delicosum* Sell.), which was inadequately described by Sellards, without a figure. The type specimen was missing from the Sellards' collection when I studied his types in 1927. Since the identification of further specimens of *delicosum* is almost hopeless, as pointed out by Tillyard, I propose to regard the name *Lecopterum delicosum* as a *nomen nudum*. *Telactinopteryx* was based upon a single species (*striatipennis* Till.) and placed in a separate subfamily. In my opinion this species does not belong to the Probnisidae. Its eyes are very small, the prothoracic lobes almost absent, the tibiae are unmodified, the cerci multisegmented, the wings lack the granulation described above in *Probnis*, and their venation is distinctly different from that of the latter genus. I therefore establish a distinct family, **Telactinopterygidae,** for this genus. *Probnis* consequently remains the only known genus of the family Probnisidae.

Genus *Probnis* Sellards

Probnis Sellards, 1909, Amer. Journ. Sci., **27**: 159; Tillyard 1937, ibid., **33**: 417

Espira Sellards, 1909, ibid., **27**: 160

Stoichus Sellards, 1909, ibid., 160

Stinus Sellards, 1909, ibid., 161

Since only one species of this genus is known, and that one species has a very variable venation, it is impossible to do more than to suggest generic characteristics. Tillyard has given a very detailed account of the venation under the genus, but nearly all of his statements are clearly specific rather than generic in nature; Tillyard himself apparently realized this, since he completely omitted description of the venation under the species. In all probability such general body characteristics as the relative size of the prothoracic lobes and the relative length of legs and cerci are of generic rank; and very likely also such general venational characteristics as the approximate position of the origin of Rs and MA are in the same category. I regard the peculiar coriaceous texture of the wings as a family trait, rather than a generic one, as it was treated by Tillyard.

Genotype: *Probnis speciosa* Sellards.

Probnis speciosa Sellards

Figures 15, 16

Probnis speciosa Sellards, 1909, Amer. Journ. Sci., **27**: 159; Tillyard, 1937, ibid., **33**: 417

Probnis coriacea Sellards, 1909, ibid.: 160

Espira obscura Sellards, 1909, ibid.: 160

Stoichus elegans Sellards, 1909, ibid.: 160

Stoichus arcuatus Sellards, 1909, ibid.: 161

Stoichus minor Sellards, 1909, ibid.: 161

Stoichus tenuis Sellards, 1909, ibid.: 161

Stinus brevi-cubitalis Sellards, 1909, ibid.: 161

Probnis sellardsi Handlirsch, 1919, Denkschr. der Akad. Wiss. Wien, **96**: 33

Fore wing: length, 9–14 mm.; width, 3–4 mm. Costal space narrow, almost always with a few veinlets, sometimes with many; Sc ending at about mid-wing, its actual point of termination usually obscure because of the vein's faintness; Sc is nearly straight in most specimens, but is distinctly curved in others; R usually joined to Sc or to the costal margin by several veinlets, which are oblique and often forked beyond the end of Sc; R1 and Rs unbranched; MA and MP consistently diverging at about the level of the origin of Rs; both MA and MP are unbranched in about 50% of the specimens, but either one or both may be forked, though the forks do not extend at most to more than a third of the wing length from the apex; MP is usually weak proximally; CuA is the strongest vein in the wing and it is also the most variable; CuA2 usually arises quite near the base of the wing. The marginal, arched branches of CuA1 vary from four to nine, the distal branches being longer than the proximal ones; CuP is always weak and straight; the anal veins are highly variable, but at least 1A and 2A are usually recognizable.

Hind wing: shorter than fore wing, 7–12 mm. in length; Sc close to margin, ending beyond mid-wing, usually with a series of short distal veinlets; R1 with longer distal veinlets between it and the costal margin; Rs arising from R1 at a point nearer the base of the wing than in the fore wing; Rs always

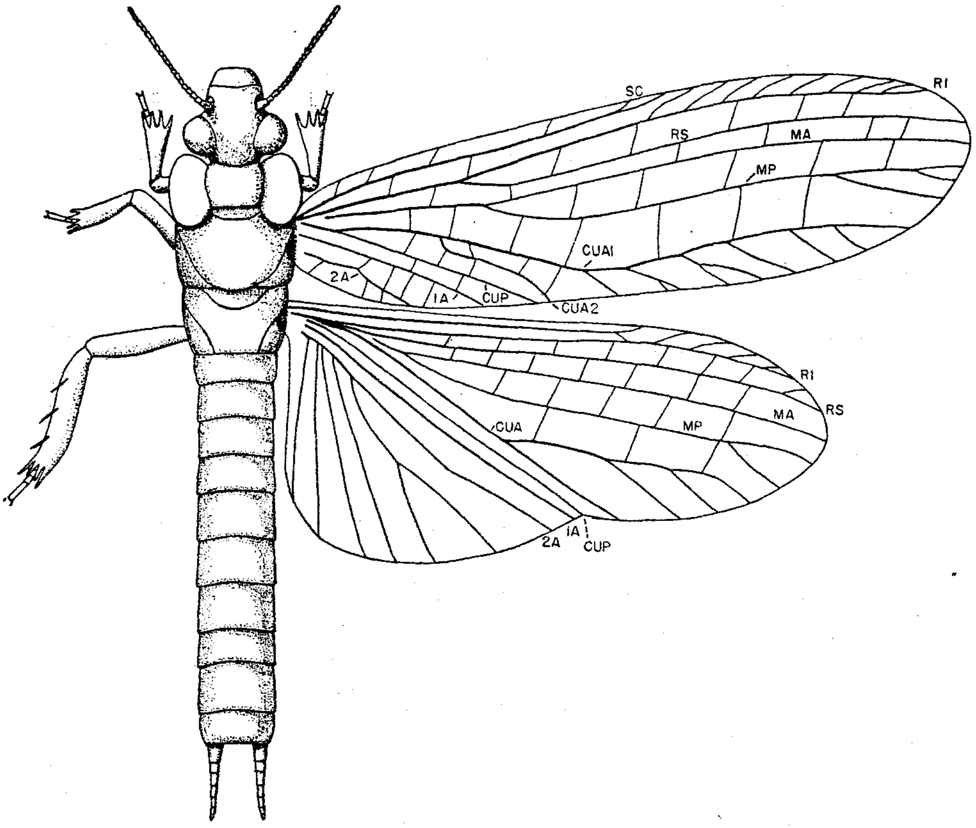

FIGURE 15. *Probnis speciosa* Sell. Restoration based on specimens in the Harvard collection. Lettering as in figure 8.

unbranched (not forked as drawn by Tillyard); MA and MP separating at a point nearer the base than in the fore wing; both may be either forked or simple; CuA with at least two distal branches, usually three; CuP straight; 1A very nearly straight; all the other anal veins may be an extension of 2A, since all arise from a single stem; the first vein below 1A is simple, the next forked and the others usually simple.

It should be noted that Tillyard's description and drawing of the hind wing of *speciosa* are incorrect in several respects. Rs arises much nearer the base of the wing than is shown in his figure and it does not fork; M is forked at about the level of the point where he has indicated the origin of Rs, instead of at mid-wing; CuA has two distal branches; between 1A and the vein which he labels 2A there is a simple straight vein. His drawing was based on an isolated hind wing in the Yale collection (15560); I have examined this specimen very carefully and compared it with hind wings in the Harvard collection. The specimen figured by him is very poorly preserved, and the anal veins connot be distinguished satisfactorily. Under oblique illumination, however, the longitudinal veins in the wing proper are distinct and their structure is essentially like that shown in the accompanying figure (15). All other specimens of hind wings of this insect, whether isolated or attached to fore wings, have a similar venation.

Many specimens in the Harvard collection show various body structures. The following description and measurements are based upon this material. The entire body, exclusive of the cerci, is about as long as the fore wing. The head, which is apparently prognathous, is about as wide across the eyes as it is long (1.8 mm.). The eyes are strongly protuberant, as they were depicted by Tillyard in his restoration of the head (1937, figure 7). The antennae, which are approximately 2 mm. long, are inserted just in front of the eyes and contain about 19 segments. The thorax is large and massive. The prothorax is small (.9 mm. long) and the prothoracic lobes are of moderate size (1 mm. long, 2 mm. wide), and slightly overlap the mesothorax. The mesothorax is the largest thoracic segment (1.5 mm. long, 2.3 mm. wide); the mesonotum is large and more or less cordate in form. The metathorax is smaller than the preceding segment (1.2

mm. long, 2 mm. wide) and has a smaller, subcordate notum. The three pairs of legs are markedly different in size. The fore pair are 3 mm. long from the base of the femur, the middle pair, 3.8 mm. long, and the hind pair 5.5 mm. long. The femur of all legs is moderately robust and of ordinary form, but the tibiae are most peculiarly modified. Each tibia terminates distally in a group of four finger-like projections.[12] The fore tibiae, which are distinctly flattened and broadened distally, bear the longest projections. The processes are obviously not moveable spines but appear to be rigid extensions of the tibia itself. Several large, oblique spines are present along the sides of the hind tibiae, though I have not seen them on the other legs. The tarsus is attached to the tibia between two of the projections, apparently slightly on the dorsal surface of the tibia. All tarsi are small (about .7 mm.); those of the hind legs are 3-segmented, the first two segments being small, and the third about three times as long as the others.[13] I have not been able to determine the nature of the segmentation of the middle and fore tarsi but it was almost certainly like that of the hind tarsi. The abdomen is nearly homonomously segmented. There is absolutely no indication of lateral gill-vestiges, like those in the Lemmatophoridae (Protoperlaria). The cerci are stout and composed of 7 segments.

Types: the holotype of *speciosa*, originally in the Sellards' collection, was lost in 1927. A neotype (no. 15518) was selected by Tillyard from the Yale material.

This insect is a common one in the Elmo limestone. Tillyard listed 99 specimens in the Yale collection; I find 37 in the Sellards' collection and about 250 in that of the Museum of Comparative Zoology. These make a total of about 385 specimens. The accompanying restoration of this insect (figure 15) is based upon several specimens in the Harvard collection. All structures shown in the figure are preserved in at least one of the fossils, except the middle and fore tarsi, which have been drawn like the hind pair.

There are two features of this species which are especially noteworthy. One of these is the texture of the wing membrane and the other is the form of the tibiae. As both Sellards and Tillyard stated, the fore wing has a distinctly coriaceous appearance. In all probability, however, the wing was not as thickened and heavy as that of even most cockroaches (such as *Blaberus*), for a great many of the specimens of *Probnis* have the fore wings twisted or folded, a condition which would hardly have taken place had the wing been very stiff. As Tillyard has mentioned, the granular appearance of the wing is produced by the presence of protuberant bases of microtrichia, which are almost evenly distributed over the surface. In only one specimen have I actually seen any of the microtrichia themselves; in this fossil they are very short and thin. Tillyard has stated his belief that the fore wings had soft, wavy hairs, forming a woolly covering. So far as I can determine, however, he did not actually see such hairs and I have failed to discern them in any specimens, including those in the Yale collection. Oddly enough, the subcosta of the fore wing was armed with a series of large spines, on the undersurface only. These spines, which are directed posteriorly extend almost the entire length of the vein. The significance of the wing texture and of the presence of the spines on the subcosta are not at all apparent; they may be in some way associated with the insect's habits or with the environment in which it occurred. In connection with the modified tibiae,

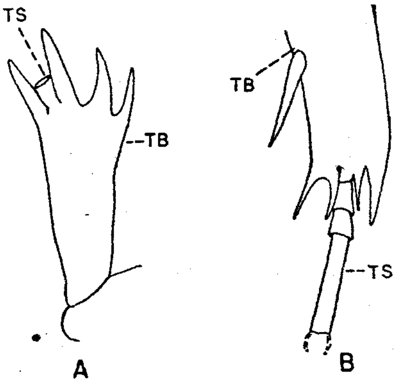

FIGURE 16. *Probnis speciosa* Sell. A, Drawing of fore tibia, based on specimen no. 4615 and 4613, Mus. Comp. Zool. B, drawing of hind tarsus and part of tibia, based on specimen no. 4619, Mus. Comp. Zool.

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[12] Tillyard's figure of the "fore leg" of *speciosa* (1937, fig. 7) does not indicate these tibial projections. My examination of the specimen on which he based his drawing (no. 15548, Peabody Museum) has shown that the leg figured was actually one of the middle pair and that the projections were broken away in the counterpart of the fossil, which was not collected. One fore leg of this specimen was preserved but it was covered by limestone matrix and was consequently not seen by Tillyard. I have subsequently removed the matrix, so that the complete tibia, with the projections described above, is now visible.

[13] Tillyard has drawn the tarsus of *speciosa* (1937, fig. 7) with 5 segments, but this segmentation was pure assumption on his part, since, as he states, none of the Yale specimens showed the tarsal segmentation.

it is noteworthy that the tarsi are distinctly suppressed. I have the distinct impression that the tarsi arose from the dorsal surface of the tibiae rather from the ventral side. The function of the tibial projections is very puzzling. They hardly seem of predatory significance, though this would be borne out by the prognathous head. The fore legs resemble those of the Gryllotalpids, and certainly suggest a fossorial function, but the structure of the other legs and of the rest of the insect does not support this indication. At present I am inclined to the belief that the tibiae might have played a part in climbing; this is consistent with the presence of the strong spines on the hind femora and of the modification of all tibiae.

In synonymizing seven of Sellards species and three of his genera with *speciosa,* Tillyard was unquestionably correct, and I have considered it unnecessary to present further evidence for this from the material in the Harvard collection. Handlirsch established one additional species for an incomplete hind wing which Sellards figured without attempting to determine its generic position. This is of course another synonym.

Nothing is known about the immature stages of *Probnis.* Tillyard has stated that the abdomen of the adult shows a mottled pattern which assisted him to recognize as belonging to this species one of the commoner larval types in the Yale collection.[14] His statement regarding the mottled pattern of the adult abdomen puzzles me greatly, for I have seen no indications of such a pattern in any specimens, including those in the Yale collection. I do not believe there is any evidence whatever for associating the nymphs mentioned with the genus *Probnis.*

Relationship of the Probnisidae

After his study of the Yale specimens Tillyard came to the conclusion that the Probnisidae were aquatic in the nymphal stages and belonged to the Order Protoperlaria, and he presented a series of arguments to support this view. I do not believe that he has really proved his case, however. It is my conviction that the Probnisidae had terrestrial nymphs and that they were Protorthopterous insects related to the Geraroidea. Before discussing the evidence bearing on this question, however, we must first consider the differences between the Protoperlaria and Protorthoptera. In my account of the Protoperlaria of the Elmo limestone (Part 7 of this series), I showed that:

1. Prothoracic lobes like those of the Lemmatophoridae (the family on which the Order Protoperlaria was based) were likewise present in at least some of the Protorthoptera and could not therefore be used to distinguish these two orders, as had been proposed by Tillyard.
2. The wing venation of the Lemmatophoridae was so similar to that of some of the Protorthoptera that this alone could not distinguish the two groups.
3. The nymphs of the Lemmatophoridae were aquatic, possessing abdominal tracheal gills and swimming legs. (This statement was based upon an extensive series of nymphs from the Elmo limestone in the Museum of Comparative Zoology.)
4. The Lemmatophoridae lacked a fully developed external ovipositor.
5. Most, if not all, of the families of Protorthoptera in the Elmo limestone included species with a fully developed external ovipositor in the female.

My final conclusions were that the Order Protoperlaria should be restricted to include only species having aquatic nymphs; and that so far as known, the Lemmatophoridae was the only family that would fit into the order as so defined.

My views on the relationship between the Protoperlaria and Protorthoptera were stated as follows: the order Protoperlaria "stands in direct evolutionary line leading to the Perlaria, although it is very unlikely that any of the genera now known were the progenitors. The fossils indicate that since the Lower Permian the evolution of this Perlarian line has resulted in the reduction of the number of tarsal segments, the elimination of the prothoracic lobes and the posterior media of the fore wing, the nearly complete loss of the vestiges of an external ovipositor and the lateral abdominal gills of the nymphs and adults. In respect to these and other features the Protoperlaria are intermediate between the true Protorthoptera and Perlaria, for 5-segmented tarsi, prothoracic expansions, an external ovipositor were possessed by at least some of the Protorthoptera. The close relationship between the Orthoptera (s. lat.) and the Perlaria is now generally recognized by entomologists, and the Perlaria are frequently regarded as Orthoptera which adopted an aquatic mode of existence in the immature stages, forming a divergent branch of the Orthoptera. The Protoperlaria of the Lower Permian appear to represent the beginnings of that divergence."[15]

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[14] Throughout his paper Tillyard uses the term *larvae* in a broad sense, i. e., including nymphs.

[15] Zeuner (1939, p. 47) has objected to the inclusion of insects with prothoracic expansions in the Protorthoptera on the grounds that "Handlirsch defined the Protorthoptera by the absence of these expansions." I am afraid that he is mistaken in this, for Handlirsch makes no mention of either the absence or presence of

In spite of these statements, which I consider to be clear, Tillyard misconstrued my remarks in his discussion of the Probnisidae, implying that I distinguished between the Protoperlaria and Protorthoptera only by the presence or absence of the ovipositor, and that I attempted to prove a correlation between the absence of a complete external ovipositor and the aquatic habitat of the nymphs. He then comes to the conclusion, which he appears to regard as original with him, that the Protoperlaria should be restricted to include "those forms which possessed aquatic larvae [nymphs.]" This is precisely the conclusion which I had previously reached.

Having adopted this restriction for the Protoperlaria, Tillyard places the Probnisidae in that order. His reasons for doing so are given by him as follows:

"Now there are nineteen specimens of larvae [nymphs] in the Yale collection. Of these one belongs to a large Protorthopteron . . . The other eighteen are all evidently aquatic types, either complete or nearly so, and they all belong quite as evidently to the Protoperlaria, and not to Plectoptera or Odonata, though both of these Orders also occur in the Kansas beds.

"While retaining completed results of my larval study for a later paper, it is necessary to state here that I have been able to recognize two quite distinct types of larvae in the Yale collection over and above those described by Carpenter, and that I feel confident that these two types represent the larvae of the genera *Paraprisca* (Lemmatophoridae) and *Probnis* respectively. As *Probnis* is one of the most abundant types represented in the collection, we should expect to find its larva fairly common also, if it were an aquatic types; and such, indeed proves to be the case.

"We now have a *prima facie* case for including the Probnisidae within the Protoperlaria. They fulfill the definition laid down by me [sic!] earlier in this paper that they should possess aquatic larvae and prothoracic expansions or lobes in the adult."

I have quoted this passage in full in order to present in Tillyard's own words the evidence for his conclusion. Briefly stated, of course, he claims to have found specimens of aquatic nymphs in the Yale collection which belong to *Probnis*. He gives two reasons for associating these nymphs with the adults of the latter genus: 1) Since *Probnis* is one of the most abundant insects represented in the Yale collection, its nymph, if aquatic, ought to be fairly common. 2) One of the "common" nymphs with aquatic modifications has an abdominal pattern like that of the adults of *Probnis*.

In my opinion, Tillyard was not justified in drawing the conclusions which he reached. Following Tillyard's death, in 1938, the Yale specimens from the Elmo limestone were turned over to me for study by the authorities of the Peabody Museum. Included in a box marked "larval types" are the nymphs to which Tillyard obviously had reference in his paper on the Probnisidae. I find in this box twenty-one nymphs (two more having turned up in the collection since Tillyard wrote his account of *Probnis*), of which fifteen are like those described by me as Lemmatophorids, and which obviously belong to that group, as stated by Tillyard. The other six specimens comprise the Protorthopteron mentioned by Tillyard and five poorly preserved nymphs which are quite different from the Lemmatophorids. These are without doubt the specimens which Tillyard regarded as the young of Probnis. Similar nymphs are present in the Harvard collection, but I did not mention them in my account of the immature stages of the Lemmatophoridae, because I felt certain that they did not belong there. All of these nymphs are characterized by having a pigmented pattern on the dorsum of the thorax and abdomen. Tillyard's statement that these nymphs are "fairly common" in the Yale collection is very surprising in view of the actual presence of only five specimens. Even in the combined Harvard, Yale and Sellards collections from Elmo, an aggregation of over 10,000 specimens, I find a total of but 15 of these nymphs. They appear to me to be very rare rather than fairly common, and as such would hardly fit Tillyard's requirements for the nymphs of *Probnis*, viz., "As *Probnis* is one of the most abundant types represented in the collection, we should expect to find its larva also fairly common if it were an aquatic type." As to the pattern on the abdomen and thorax, I have been completely unable, as stated above, to find any trace of this on the adults of *Probnis*, including the material in the Yale collection. There are, of course, the irregular blackened areas caused by the breaking away of part of the carbonized body;

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such expansions in his definition of the order (Die fossilen Insekten, 1906, p. 128). Handlirsch's statement about the prothorax is: "der Prothorax gross, oft stark verlängert." However, even if it were true that Handlirsch's definition of the order characterized the Protorthoptera by the absence of prothoracic expansions, that would not prevent the inclusion of species with them in the order. The concept of any taxonomic category, whether order, family, genus, etc., is continually being changed as new species are found. A flexible concept is especially necessary for extinct categories, since our knowledge of them is acquired only by the accumulation of a few facts at infrequent intervals.

but such areas are nearly always present in all the Elmo insects which have body parts preserved. It is possible that Tillyard misinterpreted the significance of these blackened areas, although one would suppose that he would have noted them in the Lemmatophoridae and other common species. Of course, if the adult Probnisidae actually had a mottled pattern on the abdomen even remotely resembling that of the nymphs mentioned, I would consider this strong and even conclusive evidence of the association between the nymphs and the adults.

There is one structural feature of the Probnisid adults which indicates that their immature stages were *not* aquatic. The adults of the Lemmatophoridae (Protoperlaria) possess lateral abdominal projections which have been interpreted by Tillyard and me (Carpenter, 1935, p. 143) as vestiges of the lateral tracheal gills present in the nymphs. No such structures occur in the adults of *Probnis*, as was observed by Tillyard. Now while it is of course true that the presence of such gill vestiges is not at all necessary in adults having aquatic nymphs, nevertheless their constant presence in all known genera of Protoperlaria would at least lead us to expect them (but not require them) to be present in other members of the group. Their absence in the adult Probnisidae is at least an indication, however slim, that these insects did not have aquatic nymphs.

If the nymphs of the Probnisidae were terrestrial, then the family is eliminated from the Protoperlaria, as that order has been defined. In this connection, it is pertinent to note that a comparison of the structure of the Probnisidae (adults) with that of the Lemmatophoridae, on which the order Protoperlaria was established, gives added support to the view that the Probnisidae are not so closely related to the Lemmatophoridae as Tillyard believed. The head of the Probnisids was prognathous, whereas that of the Lemmatophorids was hypognathous; the antennae of the Probnisids were relatively short and stout, whereas those of the Lemmatophorids were very long, slender, and multisegmented; the tarsi of the Probnisidae were 3-segmented and the tibiae were peculiarly modified, whereas the tarsi of the Lemmatophorids were five segmented and the tibiae were normal; the cerci of the Probnisidae were short and had few segments, whereas those of the Lemmatophorids were long and multisegmented. The venation of the Probnisidae is like that of the Lemmatophorids in most respects, it is true; but I have repeatedly pointed out that the venation of the Protoperlaria, as represented by the Lemmatophorids, and that of many of the Permian Protorthoptera are so much alike that it is not possible to distinguish ordinal differences on the wing venation alone.

It is my conviction, therefore, that the Probnisidae had terrestrial nymphs and were members of the Order Protorthoptera (suborder Geraroidea). Their closest relatives as far as known were the Lepiidae, a family represented in the Elmo limestone by *Lepium elongatum* Sellards. This latter insect, which was referred to the Protorthoptera by Tillyard, will be dealt with in the next part of this series of publications.

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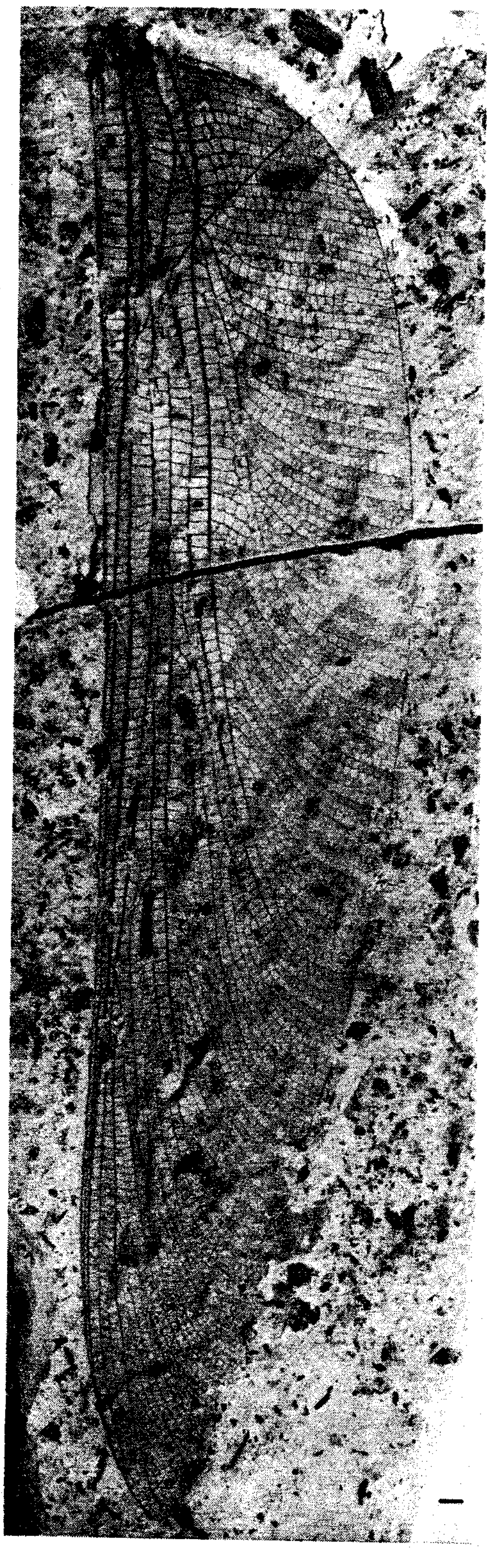
Explanation of Plate 1.

Figure 1. *Megatypus schucherti* Till. (x1) Photograph of specimen no. 4633, Museum of Comparative Zoology.

Figure 2. *Apsidoneura flexa*, n. sp. (x6). Photograph of holotype, no. 4572, Museum of Comparative Zoology.



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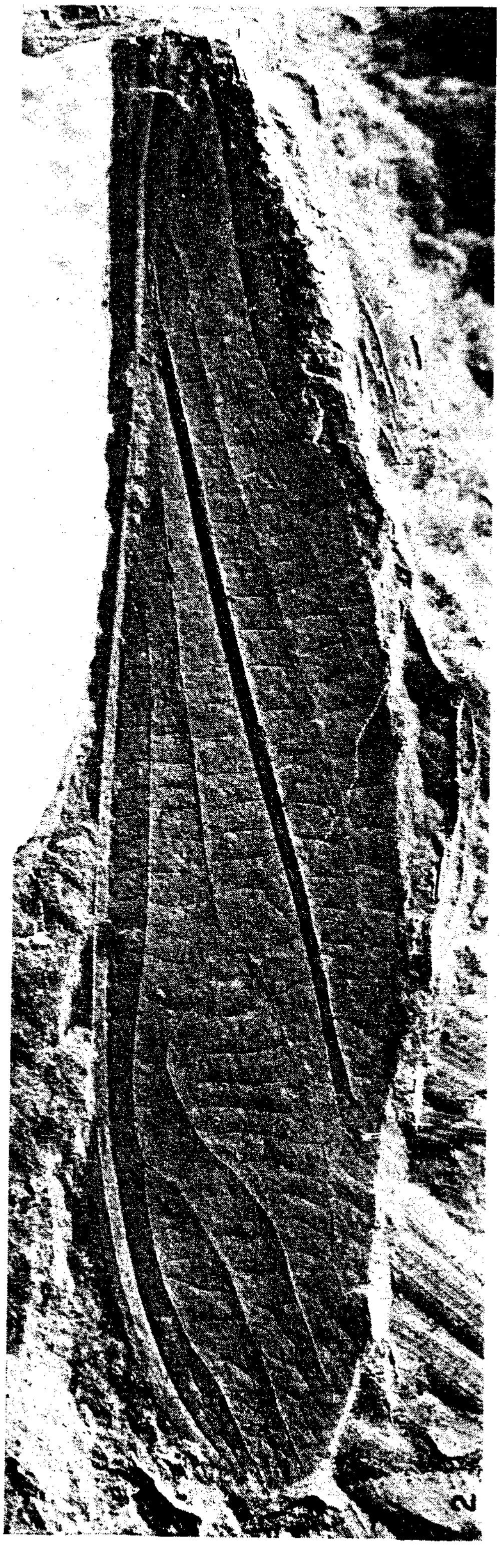

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SOME FACTORS IN THE DEFENSE MECHANISM AGAINST REINFECTION WITH *TRYPANOSOMA LEWISI*

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Early in the experimental studies on *Trypanosoma lewisi* it was discovered that rats having spontaneously recovered from an infection are refractory to reinfection (Kanthack, Durham and Blanford[1]). The immunity thus acquired lasts, with an occasional exception, for the life of the rat. The numerous immunological studies with *T. lewisi* have been chiefly centered on determining the factors involved in the recovery of rats from an initial infection (Taliaferro,[2] Regendanz and Kikuth,[3] and others).

Our knowledge of the defense mechanism against reinfection is at present meager and largely based on *in vitro* studies. Only a few observations have been made directly on the parasite during the course of reinfection. Laveran and Mesnil[4] noted that when recovered or hyperimmunized rats are inoculated intraperitoneally with living *T. lewisi* the parasites seldom appear in the circulating blood. They believed that phagocytosis was the chief mechanism involved in both active and passive immunity. Agglutination of the parasites was observed by Laveran and Mesnil, but they did not consider it an important event in the defense mechanism since the parasites were apparently uninjured by the reaction.

Recent workers have generally failed to observe typical phagocytosis of trypanosomes. Taliaferro[5] has noted trypanosomes attached to leucocytes under conditions similar to the experiments of Laveran and Mesnil and when inactivated immune rat serum was mixed with washed *T. lewisi* and washed guinea pig leucocytes. It would appear that, at the present time, phagocytosis is not considered to be the important or usual manner of destruction and disposal of *T. lewisi* in either the initial infection or in reinfection.

Taliaferro[5] injected intravenously large quantities of washed adult trypanosomes into recovered rats—but otherwise normal—and also into recovered rats splenectomized during the course of their initial infection. In the first experiments, 27 rats were inoculated from 6 to 325 days after the end of the initial infection. There was no apparent correlation between the length of time from recovery to the second inoculation and the duration of the reinfection. No reproduction by the parasites was noted in 8 rats whose reinfections lasted from 2 to 3 days. Dividing forms occurred in 6 rats whose reinfections lasted 2 to 13 days and, for the others, the trypanosomes remained in the blood too short a time to determine reproductive activity. In many of the rats recovery was apparently rapid, since "the parasites were swept from the blood in 5 to 15 minutes." To what extent reproduction developed and whether a numerical increase of trypanosomes occurred is not stated. In the splenectomized series, 10 rats were reinfected from 31 to 353 days after the end of the initial infection. The reinfections lasted from 1 to 40 days and in 2 rats "slight variation" of trypanosomes but no division was noted. It was concluded that, in most cases, the trypanocidal antibody is so strong in recovered rats that it is largely effective before the ablastin (reproduction-inhibiting antibody) has time to play any particular rôle. The nature of the trypanocidal antibody has not been determined, but according to Taliaferro,[6] it is a lytic antibody which may act as an opsonin *in vivo*. *In vivo* studies, thus far, have failed to indicate the specific character of this antibody.

From a review of the literature it would appear that in most attempts to establish reinfection the experimental animal was injected intraperitoneally with a dilute suspension of infective blood. Since trypanosomes injected into the peritoneal cavity must traverse one or more lymph nodes before they can enter the blood stream, the possibility was early considered that in spontaneous recovery the lymph nodes might become "sensitized" and thus produce an effective barrier against the parasites entering the circulation.

In the present study, experiments designed to gain information on this question clearly demonstrated that trypanosomes pass without hindrance and as readily through the lymph nodes of a rat spontaneously recovered from previous infection as they do through the nodes of a normal, susceptible rat (Augustine[7, 8]), and that they then appear with equal promptness in the circulation. Further *in vivo* studies, herein reported, revealed some phenomena in the defense mechanism against reinfection. From these studies it is apparent that ablastin, the reproduction-inhibiting antibody believed to play an important rôle in recovery from an initial infection,[5] appears to be absent or nonoperative in reinfection. Rapid recovery from reinfection appears to be due entirely to the action of the trypanocidal antibody, to which the dividing trypanosomes are particularly vulnerable, and by which they are first immobilized or killed and are then phagocytosed by the circulating mononuclear leucocytes, and by which the adult parasites are agglutinated but not killed, and are then mechanically removed from the circulation and destroyed in the liver and probably also in the spleen.

Material and Methods

The present experiments were made with the same strain of trypanosomes (*T. lewisi*) used in our earlier studies.[7, 8] It was originally obtained in 1938 by Dr. E. E. Tyzzer from a wild rat trapped in South Boston. The strain has since been maintained in the laboratory in cultures and in albino rats, originally of Wistar stock, and which are believed to be bartonella-free. The experimental rats were of this same laboratory-bred stock.

The procedures in the present series of experiments are essentially the same as those followed in our earlier studies.[7, 8] The experimental rats were injected with great quantities of trypanosomes. To obtain these, rats, previously inoculated and whose bloods were heavily parasitized, were etherized, the thoracic cavity exposed, and bled to death from the heart into a syringe containing a small amount of heparinized saline. The blood was then diluted several times with normal saline and centrifuged at a medium speed until most of the blood cells were thrown down. The supernatant fluid was then removed and centrifuged a second time for about twenty minutes at high speed. The supernatant of this centrifugation was discarded and the trypanosomes were collected with the leucocytic layer of the sediment. More saline was added to the remaining sediment of the first centrifugation, which sediment always contained an appreciable number of trypanosomes, and after one or more centrifugations and separations the trypanosomes collected were added to those already obtained. The total number of trypanosomes obtained was estimated by the usual hemocytometer method and the lot was then immediately inoculated into the peritoneal cavity of the experimental rat. The parasites in the experimental rat were studied in fresh samples of blood obtained from the tail or a toe, blood films stained by Wright's method, in fresh teased tissue in saline and in fixed sections of tissue stained with eosin and methylene blue or by Delafield's hematoxylin-eosin method. The degree of reproductive activity was evaluated by determining the percentage of parasites with a divided kinetoplast or nucleus in the stained blood preparations. A total of 200 parasites were carefully examined for evidence of cell division. Cells in the process of dividing into two or more units were counted as a single dividing cell.

Results

The first series of experiments were performed to determine if lymph nodes become effective filters against trypanosomes as a result of spontaneous recovery from previous infection. Four rats (Nos. 201, 202, 203, 204) whose initial infections lasted for about 9, 27, 44 and 69 days were each reinoculated intraperitoneally with more than 330 million adult trypanosomes 27, 37, 14 and 68 days, respectively, after the approximate end of their first infections. A fifth experimental rat (No. 307) whose initial infection lasted approximately 48 days was similarly reinoculated 112 days later with young trypanosomes undergoing rapid multiplication; the infection in the donor had been allowed to run for 5 days. Samples of blood from all 5 rats taken 5, 15 and 30 minutes following the inoculations were negative. The first positive sample was obtained after about 40 minutes from rat 202 and samples from the remaining rats were positive within the first hour. The trypanosomes were active and apparently unharmed during their journey from the peritoneal cavity through the lymphatics into the blood stream. Fluid aspirated within 30 hours from the peritoneal cavity of these rats always contained active and apparently normal trypanosomes free from host cells. None was found after 48 hours. There was no evidence of their destruction in the peritoneal cavity.

A sixth rat, No. 310, whose initial infection lasted about 44 days, was similarly reinoculated with 800 million adult trypanosomes 73 days later. Within an hour trypanosomes appeared in the circulation. The blood stream infection was transient, no parasites were found on the following day. Fifty-six days later the rat was again inoculated with 400 million adult trypanosomes. No parasites were seen in the blood samples taken up to 3 hours after the inoculation was made. The rat was then killed by a blow on the base of the skull, its chest opened and the mediastinal lymph nodes examined. Two lower nodes were enlarged and reddish, the nodes directly cephalad to these appeared normal. One of the lower nodes was removed and teased apart in normal saline. Upon microscopical examination of the material, the donor's blood cells appeared in vibrating clusters containing one or more active parasites. One of the smaller, anterior nodes was then removed and similarly examined. The preparation showed normal lymph node structures with the exception of a few trypanosomes all of which appeared normal and were free from any cell attachment. Saline washings from the peritoneal cavity contained myriads of single, normal-appearing trypanosomes.

Clumping of the donor's blood cells was not observed in our former experiments,[7,8] where the experimental rat had received but a single inoculation. In the present experiment the experimental animal received on three occasions infective material which always contained an appreciable quantity of the donor's blood cells. The phenomena which followed the third injection suggested the possibility that the successive intraperitoneal injections of the blood cells in the inoculum had caused agglutination in the gland.

The following experiment was made to gain information on this very point.

Two rats, Nos. 311a and 311b, litter mates weighing approximately 110 grams each, were inoculated with *T. lewisi* cultured on NNN medium. The infections were first apparent 6 days later and lasted about 49 days. Five days after the end of the infections each rat was inoculated intraperitoneally with 200 million adult trypanosomes, the inoculum purposely contained an appreciable amount of the donors's washed blood cells. Four hours after inoculation the rats were killed by a blow on the base of the skull and the mediastinal lymph nodes examined.

Two other rats, Nos. 312a and 312b, litter mates of 311a and 311b, were, at the beginning of the experiment, given intraperitoneally 2.5 cc. of washed blood cells from a normal rat. Similar inoculations were made at 10-day intervals, each rat receiving a total of 6 inoculations. On the fourth day after the last injection these rats were inoculated with 200 million trypanosomes, of the same material as was used for their litter mates and approximately 4 hours later the rats were killed in a similar manner and the mediastinal lymph nodes examined. If, in our earlier experiment (rat 310), agglutination in the node were due to an acquired immunity to the trypanosomes alone, we should expect to observe the phenomenon in the nodes of rats 311a and 311b. If, however, the masses were due to the repeated injections of donor blood cells in the inoculum, we should expect agglutination and retention of parasites in lymph nodes of rats 312a and 312b.

Upon gross examination of the mediastinal lymph nodes, one or both of the paired lower nodes of all four experimental rats were distended and reddish in color from absorption of donor blood cells. The cephalad nodes were normal in appearance. These nodes were removed separately and teased apart in saline. Upon microscopic examination of the preparations none showed the slightest evidence of agglutination of the donor's cells. In every case the trypanosomes moved freely among the blood cells without hindrance. It would appear, therefore, that intranodal agglutination of the donor's cells in the case of rat 310 was a singular phenomenon comparable to the occurrence of isoagglutinins and isolysins rarely observed in laboratory animals (Ingebrigtsen,[9] Fishbein,[10] and others).

From the results of these first experiments it can be concluded that *T. lewisi*, when inoculated into the peritoneal cavity of rats spontaneously recovered from a previous infection, readily progresses into the lymphatics, passes without hindrance through the lymph nodes and promptly appears uninjured in the blood stream. The filtration accomplished here is, therefore, identical to that which occurs when the parasite is similarly inoculated into normal susceptible rats.[7]

MECHANISM IN RECOVERY FROM REINFECTION

The following experiments are chiefly concerned with the interactions of host and parasite following the entrance of the trypanosomes into the circulation of the rat recovered from one or more previous infections. In the first group the experimental rat was inoculated with adult trypanosomes, *i. e.* the infections in the donor rats were all 15 or more days old. In the second group the analogous inoculations were made with trypanosomes from infections only a few days old which showed many of the parasites undergoing multiplication.

A typical experiment of the first group was as follows:

November 10, 1939. Experiment 4.*

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* See Augustine[8] for a detailed account of the initial injection in the experimental rat.

Initial Infection

11:55 A.M. Experimental rat 4, weight 75 gm., injected intraperitoneally with 250 million adult trypanosomes.

12:15 P.M. Trypanosomes present in drop of blood from tail.

November 12.

10:45 A.M. Multiplication of trypanosomes started. Few normal trypanosomes in fluid aspirated from body cavity.

November 16.

10:00 A.M. 185,000 trypanosomes per c.mm. blood. Rate of reproduction diminished. No trypanosomes from peritoneal cavity.

January 13, 1940.

Approximate end of initial infection.

Reinfection

March 27.

11:45 A.M. Weight 240 gm. Blood negative, 400 million washed adult trypanosomes injected intraperitoneally (second inoculation).

12:45 P.M. Small drop of blood from tail contains 2 trypanosomes.

4:45 P.M. Less than 5,000 trypanosomes per c.mm. blood. Numerous free, normal-appearing trypanosomes in fluid aspirated from peritoneal cavity.

March 28.

10:00 A.M. 15,000 trypanosomes per c.mm. blood, normal, no variation in size or shape, no multiplication. Many normal trypanosomes in fluid from peritoneal cavity.

4:00 P.M. No change from that at 10:00 A.M.

March 29.

9:15 A.M. 20,000 trypanosomes per c.mm. blood. Some variability in size noted; 0.5 per cent dividing cells. A new normal trypanosomes in fluid from peritoneal cavity.

2:15 P.M. No change.

9:30 P.M. No change.

March 30.

9:00 A.M. Numerical count unsatisfactory. Clusters consisting of up to 40 to 50 parasites present in blood samples from tail and toes. The trypanosomes are attached by their posterior tips, their flagella free (figs. 1 and 2). Smaller formations consisting of 2, 3, 4, and 5 individuals similarly attached and single parasites also present. The clusters are free of any attachment to the blood cells. Stained smears show an occasional dividing cell included in the clusters of adult trypanosomes. Blood examinations made hourly up to 5:00 P.M. show no apparent change. No trypanosomes in washings from peritoneal cavity.

March 31.

1:00 A.M. Blood samples taken from tail and toes contain many agglutinated masses of trypanosomes and a few single parasites. Stained smear shows one dividing cell containing 4 nuclei and 4 kinetoplasts in an agglutinated mass of adult trypanosomes.

2:00 A.M. to 6:00 P.M. Samples of blood taken hourly show no apparent change except that fewer trypanosomes were present in the last samples taken.

April 1.

8:30 A.M. No large agglutinated masses. A few formations of 2 and 3 individuals and a few single trypanosomes (all active) present.

1:00 P.M. No agglutinated parasites seen in several samples of blood. A few single, apparently normal adult forms present.

April 2.

10:00 A.M. No trypanosomes found in many samples of blood. Several drops of blood were collected in 3 cc. normal saline of which 3 one-month-old rats (litter mates) Nos. M, N and O each received 1 cc. intraperitoneally.

11:30 A.M. Rat 4 (the experimental animal) reinoculated intraperitoneally with 380 million washed adult trypanosomes.

1:30 P.M. A few single trypanosomes in sample of blood from tail. Fluid aspirated from peritoneal cavity contains myriads of active, apparently normal trypanosomes.

April 3.

9:30 A.M. No trypanosomes found in several samples of blood taken from the tail and toes. Trypanosomes relatively numerous in fluid aspirated from peritoneal cavity, all normally active. Several drops of blood collected in 3 cc. normal saline of which 3 rats, Nos. P, Q and R (litter mates of Nos. M, N, O) each received 1 cc. intraperitoneally. Fluid aspirated from peritoneal cavity of rat 4 similarly inoculated in rat S, 2 weeks old.

April 4.

9:30 A.M. No trypanosomes found in samples of blood or in saline washings for peritoneal cavity of rat 4.

April 8.

2:00 P.M. Rat 4 negative. Blood samples from rats M, N, O, P, Q and R negative. Blood of rat S swarming with trypanosomes.

April 11.

9:15 A.M. Rat 4 negative. Blood samples from rats M, N, O, P, Q and R negative. Blood of rat S swarming with trypanosomes.

April 15.

10:00 A.M. No change in conditions in all rats from that on April 11.

January 14, 1941.

3:00 P.M. Rat 4. Weight 245 gm. Blood negative for trypanosomes. Reinoculated intraperitoneally (third inoculation) with 800 million washed, adult trypanosomes.

3:45 P.M. Trypanosomes in blood sample from tail.

January 15.

9:00 A.M. 105,000 trypanosomes per c.mm. blood. No dividing cells. Numerous active, normal trypanosomes in fluid aspirated from peritoneal cavity.

January 16.

9:00 A.M. 95,000 trypanosomes per c.mm. blood, 0.5 per cent dividing cells. Very few trypanosomes in fluid obtained from peritoneal cavity.

January 17.

9:00 A.M. 80,000 per c.mm. blood in which small agglomerations noted. No parasites in fluid from peritoneal cavity.

January 18.

9:15 A.M. Blood samples show trypanosomes agglutinated. Single trypanosomes also present.

January 19.

9:30 A.M. Blood samples negative. Rat killed with ether. Autopsy shows no gross pathology; tissues removed and fixed for later study.

The experiments of this group quite clearly demonstrate that when recovered rats are injected intraperitoneally with adult trypanosomes the parasites arrive promptly and uninjured into the circulating blood. Reinfection may last for a few minutes only in some rats while in others it may last for several days. The difference in the duration of reinfection is probably due to differences in titer of the trypanocidal antibody in different animals at the time the transfer is made. Reproduction by the parasites usually started where reinfection lasted for 2 days or longer. Reproduction was never successful. The parasites were agglutinated but not killed in blood stream and then mechanically removed before a numerical increase in the parasite population could be evaluated. It appeared that their destruction might then take place in the liver and spleen by the action of the phagocytic cells of the reticulo-endothelial system.

A study of the stained sections of liver, spleen and bone of rat 4 revealed no pertinent pathology. We could scarcely expect to find evidence of destruction of the parasites in the tissues since several hours may have passed between the disappearance of the parasites from the blood and the killing of the rat for post mortem study.

Precise information on the fate of the agglutinated masses of trypanosomes was obtained from a study with experimental rat No. 20. This rat was reinoculated about 23 days after the end of its initial infection with more than 900 million washed adult trypanosomes. It was killed with ether on the morning of the third day of reinfection at which time the blood was swarming with large agglutinated masses of trypanosomes. The rat was immediately autopsied and tissues fixed for later study. The spleen was 3.5 cm. long, all other organs appeared normal. Bits of liver, spleen and bone marrow teased apart in saline showed fairly numerous active trypanosomes, most of which were single and without attachment to any host cells. A few agglutinated masses were present in the preparations of liver and spleen. Stained sections of the liver show normal-appearing trypanosomes in the larger blood vessels while in the small vessels remnants of agglutinated parasites with entangled flagella are present (fig. 5). The macrophages show evidence of phagocytic activity but we have not been able to identify any of the inclusions as parts or remnants of trypanosomes. Normal-appearing single trypanosomes and small agglomerations of trypanosomes are occasionally found in vessels of the spleen. No remnants of the parasite have been identified in the spleen but the amount of cytoplasmic inclusions in the phagocytes is marked. No parasites were found in stained sections of the femur or in stained smears of bone marrow.

A study of our stained blood smears shows that the parasites started to multiply in every instance where the second or later infection lasted more than 2 days. Size variation occurred first which was followed by the appearance of individuals with double nuclei or double kinetoplasts and an occasional cell containing 4 nuclei and 4 kinetoplasts. Reproduction was not sufficient to cause numerical increase, as the parasites were agglutinated and removed from the circulation before a numerical increase could be evaluated. Dividing cells are frequently found in the agglutinated masses. No evidence was found, either in the fresh blood preparation or in the stained smears, that the agglutinated mass contained dead parasites. The last trypanosomes seen in the blood following the disappearance of the agglutinated masses have always been adult forms. They have been few in number, frequently only a single parasite in several fresh preparations and are seldom found in the stained smears. Their life span in the blood is short, seldom longer than an hour after the disappearance of the agglutinated masses. The manner of their disposal is not known.

From the results of these and pertinent parts of seventeen other similar experiments it is apparent that when adult trypanosomes are injected into the peritoneal cavity of rats recovered from one or more previous infections they readily enter and progress through the lymphatic system, pass uninjured through lymph nodes and promptly appear in the blood circulation. They are then agglutinated, but not killed, in the blood stream and are mechanically filtered out and destroyed in the internal organs. When the blood stream infection lasted more than 2 days the trypanosomes invariably started to multiply but the parasites were agglutinated and removed from the circulation before any appreciable increase in numbers occurred. It is also apparent from the results obtained here that the trypanocidal antibody is definitely localized in the blood and has no effect upon trypanosomes remaining in the peritoneal cavity.

In the above experiments the time in which the parasites were demonstrable in the blood varied from a few minutes to 5 days. As a rule, the elapsed time from the end of the initial infection to the second infection showed no correlation with the duration of the second infection. Such variation would appear to be due to difference in the ability of different rats to produce and retain trypanocidal antibody, or in other words, differences in the titer of this antibody at the time of reinoculation.

Since there was a definite attempt by the parasites to multiply, it seemed likely that successful, or at least an appreciable multiplication in such animals might develop from inoculations made with young, dividing trypanosomes which, as we previously demonstrated,[8] continue to multiply without interruption when transferred to a new, susceptible host. The following experiments are concerned with reinfection from dividing trypanosomes and the defense reactions in the immune host.

A typical experiment of this type follows:

April 16, 1940. Experiment 300.

Experimental rat No. 312, weight 220 gm., inoculated intraperitoneally with washed adult trypanosomes. A normal infection (initial infection) developed which terminated approximately May 23.

January 20, 1941. Weight of rat 215 gm.

10:15 A.M. Inoculated with 400 million trypanosomes collected from a rat with an initial infection 5 days old. 4.0 per cent dividing cells.

11:20 A.M. Many trypanosomes present in samples of blood from tail.

January 21.

9:30 A.M. 80,000 trypanosomes per c.mm. blood, 4.0 per cent dividing cells, size variation marked.

January 22.

9:30 A.M. 85,000 trypanosomes per c.mm. blood, 3.0 per cent dividing cells. Size variation marked.

January 23.

9:00 A.M. 50,000 trypanosomes per c.mm. blood, 1.0 per cent dividing cells. Size variation marked.

January 24.

9:00 A.M. 55,000 trypanosomes per c.mm. blood, 0.5 per cent dividing cells. Size variation not prominent.

January 25.

9:30 A.M. Trypanosomes agglutinated, numerical estimation unsatisfactory. Adult trypanosomes only, 0.05 per cent of which show double nuclei.

January 26.

9:45 A.M. Only a single, adult trypanosomes present in several fresh blood samples. A total of 9 adult trypanosomes found on two large stained blood smears.

Blood samples taken January 27, 29 and February 20 negative. The rat was in a weakened condition on February 20 and was found dead the morning of February 23.

Experiments of this type show again that trypanosomes, in reinfection, are ultimately agglutinated in the circulation and are then removed from the blood stream. However, where the second inoculation was made from 6 to 18 months after the end of the initial infection the attempt of the parasites to multiply without affecting any appreciable numerical increase was a constant feature. It was also characteristic, as in the above experiment, for the percentage of dividing cells to decrease in number on successive examinations and reproduction to stop just prior to the event of agglutination, leaving only adult trypanosomes or rarely a dividing cell in the blood.

The study of the stained blood smears from rat 312 at first appeared to offer an acceptable explanation for this lack of an increase in the number of trypanosomes during the early stages of reinfection.

Blood smears made on January 21 show nothing unusual. On January 22 and 23, however, remnants of trypanosomes, free flagella, undulating membranes with the kinetoplast attached, and ruptured trypanosomes discharging their contents were frequently noted. Vestiges indicating that the parasite was undergoing division at the time of its destruction are prominent (figs. 3 and 4). It is not possible, however, to determine whether all of the vestiges are derived from dividing cells since, in many instances, the more fragile cell elements, including the nucleus, are degenerate or lacking. The vestiges are single, free of any blood cells, they lie next to uninjured trypanosomes and normal blood cells and are more or less evenly distributed over the entire smear. The relative daily frequency of these remnants in a count of 400 trypanosomes for the present experiment is: 0.05 per cent January 22, 1.5 per cent January 23, 0.05 January 24, and none on January 25. Thus, their structure and their simultaneous presence and disappearance with dividing parasites support the view that they are derived from cells undergoing, or about to undergo, active division.

The above observations suggested a lytic action on the parasite outside the macrophage. They also suggested that the dividing cell might be particularly vulnerable to this extracellular lytic action of the antibody, but to which the adult forms remained nonsusceptible until the titer of the antibody increased to a point at which they, the adult trypanosomes, became agglutinated, but not killed in the circulation, and then were mechanically removed from the circulation. Further studies, in which the entire course of reinfection in the blood stream was viewed with dark-field illumination showed that, while we were correct in the supposition that the dividing parasites may be affected first by the trypanocidal antibody, the chief mechanism of their destruction was found not to be by extracellular lysis.

In the final group of experiments the trypanosomes were inoculated directly into the heart of the recovered rat. The parasites were thus placed directly in the blood and could be constantly observed throughout the course of the blood stream infection. Fresh, undiluted blood preparations were examined at approximately three-minute intervals with direct and darkfield illumination. Blood smears were also made for later study.

The following experiment is typical of this group:

Rat No. 406 was inoculated intraperitoneally on March 10, 1942, with a few adult *T. lewisi*. The infection which developed ran the typical course and terminated about 39 days later. On May 5, about the 17th day after the end of the initial infection, trypanosomes were collected from 2 young rats which had been inoculated 4 days earlier with adult parasites. The trypanosomes for these donor rats showed marked size variation with 3 to 4 per cent of the cells undergoing active division. The parasites were finally concentrated in 1 cc. saline of which 0.5 cc. were injected directly into the heart of experimental rat 406, previously etherized. As quickly as possible, a very small drop of blood was obtained from the tail of this rat. With direct light and the high dry lens of the microscope a number of large trypanosomes were first noted struggling to free themselves from masses of blood platelets. Other trypanosomes were single and appeared normal. The preparation was then examined with dark-field illumination. Nothing noteworthy was observed. In the second preparation some agglutinization of the parasites was observed. With dark-field illumination several large motionless trypanosomes were seen floating in the serum while others were rapidly being ingested by macrophages. Actual seizure of the immobilized trypanosome by a macrophage was not observed, but ingestion always began at the posterior end of the trypanosome, the flagellar end being the last to disappear within the phagocytic cell. Marked agglutination was found in the third preparation with continued phagocytosis of single parasites. A very few single parasites, uniform in size, were found in the fourth preparation but none was seen in the fifth and the several subsequent preparations. The parasites had been removed from the blood within about 15 minutes.

The same experimental rat was then similarly reinjected with the remaining 0.5 cc. of the inoculum. The first drop of blood again swarmed with single trypanosomes. The same phenomena in recovery were again observed. The rat died about 15 minutes after the injection was made at which time a few single trypanosomes were present in the blood.

Blood smears made before and immediately after the first inoculation show nothing of particular note. Markedly increased phagocytosis occurs in the later smears, but the cytoplasmic inclusions of the mononuclear leucocytes cannot be identified with certainty as remnants of trypanosomes. Trypanosomes occur frequently within clumps of blood platelets, an observation which would not be considered of importance or noteworthy had living trypanosomes not been seen struggling to free themselves from masses of platelets in the fresh preparations. Remnants of trypanosomes, ruptured cells and free undulating membranes with attached kinetoplasts are fairly numerous in the second and third smears made. As in earlier experiments, these remnants are more or less evenly distributed over the slide, are unattached and the majority indicate that they are vestiges of dividing cells. As none of these vestiges was seen in the fresh preparations, particularly looked for here and elsewhere with dark-field illumination, it is believed that they are remnants of the large sensitized or killed trypanosomes seen floating in the fresh preparations which, because of the action of the trypanocidal antibody, have been rendered particularly fragile and have burst on the slide during the technical preparation of the blood smear. We obtained no evidence of extracellular lysis of the parasites.

DISCUSSION

From the experimental findings just described it is apparent that trypanosomes (*T. lewisi*) pass as readily through lymph nodes of immune rats as they do through lymph nodes of a normal, susceptible rat. When these parasites are injected intraperitoneally in an immune rat they suffer no apparent injury during a temporary wait in the peritoneal cavity or from passing through its lymph nodes.

Reinfection is usually of short duration, lasting, in our experiments, from a few minutes to several days, but usually not longer than 4 days. The life span of the parasites in the circulating blood of the immune rat is chiefly determined by two important factors: (1) the titer of the trypanocidal antibody and (2) the particular phase of the infection, *i. e.* age of the parasite, at the time of transfer. The results of our experiments indicate that dividing trypanosomes are particularly vulnerable to the trypanocidal antibody. They are almost immediately sensitized with it, being killed or at least immobilized, and are then engulfed by blood macrophages. Adult trypanosomes, however, appear more resistant to the trypanocidal antibody and are not immobilized or killed by it, but when the titer of the antibody reaches a certain point, the adult parasites are agglutinated and the living, agglutinated masses are then mechanically filtered out and disposed of in the internal organs. Dividing cells may also be agglutinated along with adult forms. While we have not been able to recognize vestiges of trypanosomes in tissue macrophages we have found remnants of agglutinated parasites in the small vessels of the liver (fig. 5). This evidence and the presence of an increased amount of debris in the Kupffer cells furnish convincing evidence that the agglutinated masses of trypanosomes are removed from the circulation chiefly in the liver, and probably also in the spleen, and that they are finally disposed of in these organs by the phagocytic action of the elements of the reticulo-endothelial system.

Thus, the mechanics in recovery from reinfection with *T. lewisi* are strikingly and fundamentally different from those described in recovery from the initial infection. According to Taliaferro,[2] and others, there are three manifestations of resistance against the parasite in the course of the first infection: (1) the retardation and final inhibition of reproduction of the trypanosomes by about the 10th day by a development of an acquired immunity involving an antibody now known as ablastin; (2) a sudden destruction of most of the circulating trypanosomes by the action of a trypanocidal antibody and (3) the total disappearance of the parasites which terminates the infection and occurs from a week to several months after the first drop in numbers. Although the specific action of the trypanocidal antibody has not been demonstrated in the whole blood of recovered rats, the current opinion seems to be that it functions as an extracellular lysin.

Our experiments have given no indication that ablastin functions in recovery from reinfection. It is true that the parasitic population in the blood of the immune rat does not increase, but this failure is not due to an inhibition of reproductive activity. On the contrary, reproduction may be initiated, or may continue for some time in the circulation. However, the dividing cells are particularly susceptible to the action of trypanocidal antibody and they succumb as quickly as they are formed. Thus, an increase in the parasite population is checked, but reproductive activity is not inhibited.

The results of the present experiments leave little doubt as to the precise functions of the trypanocidal antibody. Direct observations have shown that it sensitizes the dividing cells which are thus rendered vulnerable to the phagocytic cells of the blood, and that it agglutinates the adult parasites which are then mechanically removed from the circulation. It is possible that we are dealing with two distinct antibodies, (1) an opsonin which acts specifically on dividing trypanosomes and (2) an agglutinin which agglutinates both adult and dividing forms. At present, however, we prefer to regard the trypanocidal antibody as a single sensitizing agent, the different manifestations being due to differences in its titer and to differences in susceptibility of dividing and adult parasites.

The results we obtained from experimental rat 4 clearly illustrate how strictly the trypanocidal antibody is localized in the blood. On April 2 this rat had, from all appearances, just recovered from a previous infection when it was again inoculated intraperitoneally with millions of trypanosomes. On the following day fluid aspirated from the peritoneal cavity swarmed with trypanosomes which produced infection when transferred to another rat. No trypanosomes were found at the time in the blood of rat 4, nor did the blood carry infection when it was inoculated into young rats. From the results of our earlier studies,[7, 8] it is obvious that trypanosomes were constantly arriving in the blood from the peritoneal cavity at the time. It would, therefore, appear that the titer of the antibody in this hyperimmune animal was particularly high and that the parasites were destroyed as soon as they were exposed to the antibody, *i. e.* as soon as they entered the blood stream.

SUMMARY

Experiments concerning factors in the defense mechanism against reinfection with *Trypanosoma lewisi* are reported. It has been shown that this parasite passes readily and uninjured through the lymph nodes of rats spontaneously recovered from a previous infection.

It is not apparent that ablastin plays any role in recovery in reinfection. The disposal of the trypanosomes depends exclusively on the action of a humoral trypanocidal antibody to which dividing parasites are highly susceptible and to which the adult forms are relatively resistant. Dividing cells appear in the circulating blood, but are soon killed or immobilized by the antibody and they are then destroyed in the circulating blood by phagocytosis. At a sufficiently high titer of the antibody the adult parasites are agglutinated, but not killed. The agglutinated masses of living parasites are mechanically removed from the circulating blood and then destroyed in the liver and probably also in the spleen.

The possibility of two distinct trypanocidal antibodies functioning in recovery from reinfection is considered.

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PLATE I

FIGS. 1, 2, 3, and 4 stained by Wright's method. FIG. 5 stained with eosin methylene blue.

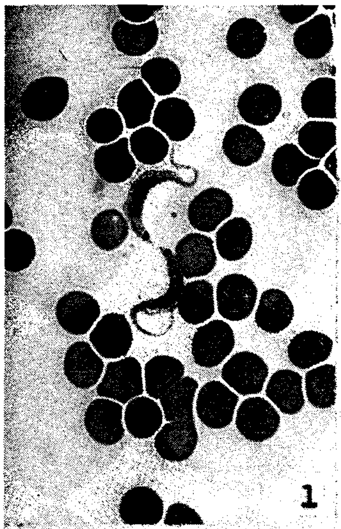
FIG. 1. Agglutination of two trypanosomes showing the characteristic manner of attachment. × 900.

FIG. 2. Two large masses of agglutinated trypanosomes, the attachment slightly distorted by drying of the film. × 900.

FIG. 3. A ruptured dividing trypanosome adjacent to an uninjured adult parasite. × 1160.

FIG. 4. A vestige of a trypanosome showing a lobed kinetoplast and surrounded by uninjured adult parasites. × 1160.

FIG. 5. Section of liver showing remnants of an agglutinated mass of trypanosomes in a blood vessel. Only one free flagellum is clearly seen in the photograph. × 1600.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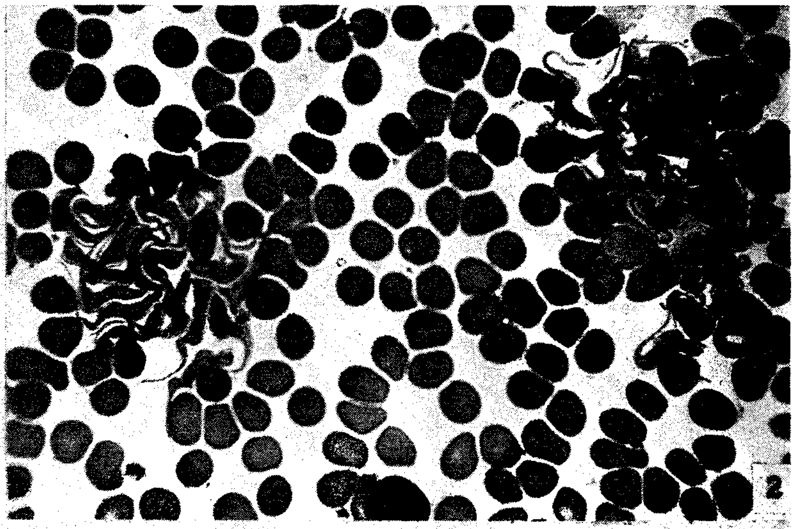
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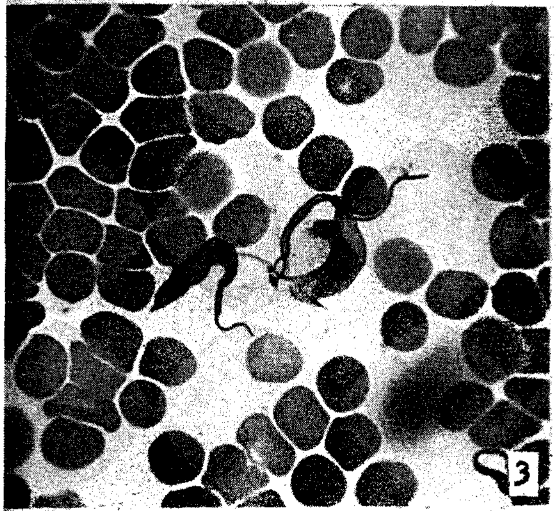
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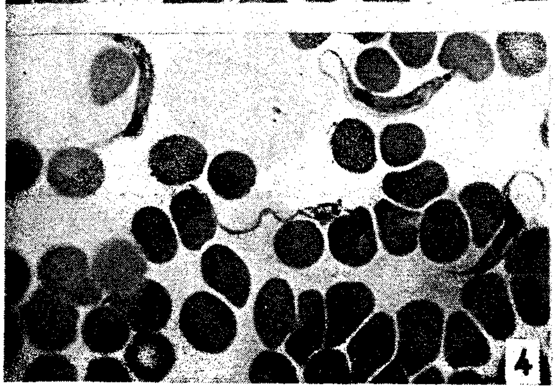
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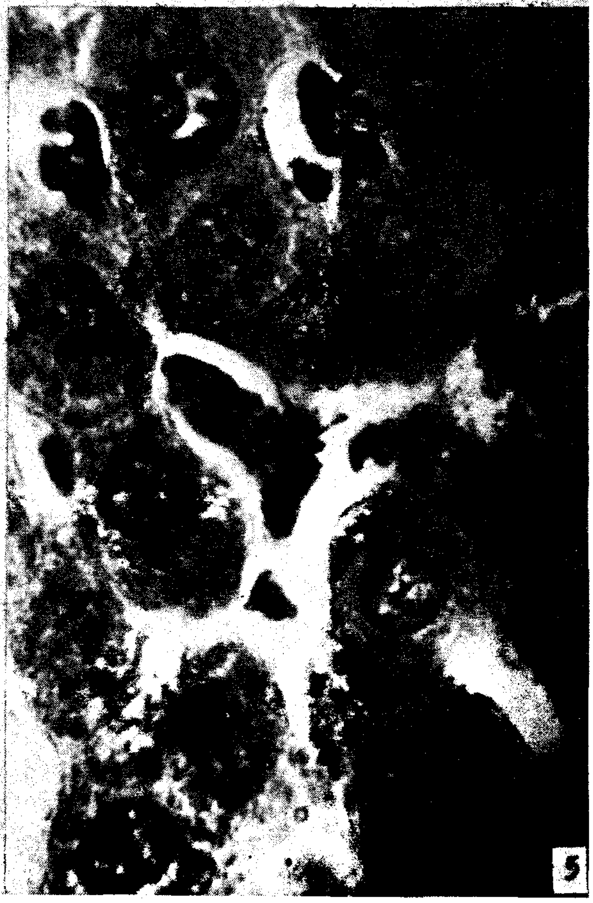
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CHAO HSÜEH-MIN'S OUTLINE OF PYROTECHNICS
A CONTRIBUTION TO THE HISTORY OF FIREWORKS

by

Tenney L. Davis and Chao Yün-ts'ung 趙雲從

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The history of fireworks is very obscure. It is generally believed that pyrotechnic mixtures of saltpeter with sulfur and charcoal, or with other materials, were invented in China at an early time and were used for entertainment, for purposes of magic as in the exorcising of demons, and later in the military art. A knowledge of these mixtures presumably found its way to Europe over the trade routes to Byzantium. The celebrated *Liber ignium ad comburendos hostes* of Marcus Graecus, which was probably written in Greek in the eighth century, describes Greek fire and other incendiaries as well as black powder and the use of the latter material in firecrackers and in primitive rockets without sticks. The writings of Roger Bacon in the thirteenth century, which contain what is supposed to be the earliest reference to black powder in Latin Europe, make mention of the fact that toy firecrackers were already in use by the children of the time. Modern improvements, the use of chlorate and perchlorate in colored fire compositions, strontium and barium salts to color the flame, and magnesium and aluminum to impart brilliancy, have come in since 1800; they are recent enough to be dated, and certain of them may probably be set down as the inventions of particular men. But it is not known who invented the Roman candle, the rocket, the flying pigeon, the catherine wheel and the saxon, and it is not known when or by whom such familiar and much-used substances as arsenic sulfide, antimony sulfide, verdigris, calomel, and iron and steel filings were introduced into pyrotechny.

The literature of fireworks is meager. Contemporary books in European languages are few and far between, and are issued in such small editions that they quickly become out of print. Books before 1800 are rare without exception, but they are especially valuable to students of the history of pyrotechnics for the reason that they antedate modern improvements and indicate the state of the art during a time when it was advancing with exceeding slowness. Fireworks in the eighteenth century were but little advanced over those of the seventeenth century. The latter showed considerable improvement over those of Marcus Graecus in the mechanical devices in which they were applied but very little in the materials from which the compositions were made. During seven or eight centuries the addition of each new substance to the list of the pyrotechnist's materials must have represented a real achievement.

The Chinese text which is under discussion in the present paper is the only Chinese text on civil pyrotechnics[1] which we have been able to find. It represents an art which is more highly developed in some respects than the pyrotechnic art of eighteenth century Europe, an art which apparently grew up entirely independently in China. It lacks certain things which were common in European treatises, and it mentions certain things which would certainly have been copied in Europe if they had been known. It appears to be wholly Chinese.

The *Huo-hsi lüeh* 火戲略 (Outline of Pyrotechnics) by *Chao Hsüeh-min* 趙學敏 is printed in the collection, 昭代叢書[2] where it has a postscript by *Yang Fu-chi* 楊復吉 which is dated 1753. It was therefore in existence at that date. A short biography of its author is included in the *Hang-chou fu chih* 杭州府志 (Record of the District of *Hang-chou*) 150.16 b–17a (1923 ed.), and considerable information about him and about his father, his brother, and his own work in medicine is given in his two prefaces to his famous Supplement 拾遺 to the *materia medica*, *Pên-ts'ao kang-mu* 本草綱目.[3] The prefaces are dated 1770 and 1765, but they contain no reference to their author's age at the time when they were written.

Chao Hsüeh-min, whose *tzŭ* was *Shu-hsien* 恕軒,

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[1] Dr. A. W. Hummel, Chief of the Division of Orientalia, Library of Congress, has kindly directed our attention to two earlier texts on military pyrotechnics, and has made it possible for us to procure microfilms of them. We hope to report upon these shortly.

[2] Volume 170 of the edition in the Library of Congress.

[3] We wish to make grateful acknowledgment to Dr. A. W. Hummel for giving us references to this material, to Dr. *Ch'iu K'ai-ming* 裘開明 for finding it for us in the Library of the Harvard-Yenching Institute, to the Harvard-Yenching Institute for the use of its text of the *Huo-hsi lüeh* and for the use of the Chinese type which has been employed in the present printing, and to Professor James R. Ware of Harvard University for reading the manuscript and for valuable criticism and suggestions.

was a native of *Ch'ien-t'ang* 錢塘 in *Hang-chou* (Chehkiang Province). He lived during the *Ch'ien-lung* 乾隆 era (1736–1796). His father was Salt Commissioner of *Hsia-sha* 下砂 county. The story goes that his father longed for sons. One day, when he was in *Ching-k'ou* 京口, he met a stranger who said to him, "According to your physiognomy, you will not have any successor, but, if you do beneficial relief work, you may get sons." There was an ocean flood which caused the death of hundreds of thousands of people. He did his best to rescue them and to bury the dead. In the autumn a plague followed, and he again contributed his salary to help, to procure medicines and the services of physicians. Thousands of lives were saved in consequence. He also suggested to the government a plan for the building of a dike. The officers in charge allowed the plan to be heard by the Emperor, and it was approved. Before any action was taken, many fields were badly damaged by the ocean tides, and seven counties, *Hsia-sha*, *Shih-yen* 石堰, *Ch'uan-shan* 穿山, *Ming-hao* 鳴鶴, *Lung-t'ou* 龍頭, etc., were inundated. He managed however to build the dike himself, and when it was finished he named it *Li-chi* 利濟 (Beneficial Relief). In the autumn of that year the ocean tides came again, but they were stopped by the dike and no damage was done. Later he was moved from this post to hold office in *Yu-ch'i* 尤溪. And so it came about that his sons, *Hsüeh-min* and *Ch'iai* 楷 were born, and were given the baby names of *Li* 利 (Beneficial) and *Chi* 濟 (Relief). When the father retired from his post, he also gave his hall the same name of *Li-chi*.

The father wished one of his sons to study Confucius and the other to study medicine. *Ch'iai*, the younger, studied the teachings of Confucius but also studied the canons on typhoid and on fevers. In his leisure time he was taught "to draw the copper man diagrams" [study acupuncture] for fun. From spring to winter the brothers studied in the Nourishing Essence Garden 養素園, which was fifty *mou* 畝 of land (more than six acres) devoted to the cultivation of medicinal grasses. *Hsüeh-min* encouraged his brother to specialize in medicine (*Ch'i-Huang* 岐黃) in accordance with the wish of his father. Although *Ch'iai* did not have confidence enough in himself to practice medicine publicly, relatives and friends who called upon him for diagnosis and who took his medicine were all cured of their diseases. He wrote a work entitled "Mirror of Herbs" 百草鏡 in 8 *chüan* 卷, and another on "Saving Lives from the Ocean of Sorrows" 救生苦海 in 100 *chüan*.

Chao Hsüeh-min was a great reader. It was his custom to continue his reading into the night. He says that he liked especially to read about the stars and the calendar, about medical subjects, and about divination and alchemy. When he found anything which interested him, he was so pleased that he forgot fatigue; he copied it or summarized it, and filed the material in packages. In this way he accumulated several thousand *chüan*. In the first of the prefaces which accompany his Supplement 拾遺 to the *Pên-ts'ao kang-mu*, he says that he almost became tired of this kind of work, and that once, when he had the time available to look them over, he picked out those which he thought to be useless and threw them in the furnace. He wrote *Li-chi shih-êrh chung* 利濟十二種 (Twelve Books from Li-chi Hall), as follows—

1. The Best Works of the Medical World 醫林集腋, 16 *chüan*,
2. Transmitted Trustworthy Formulas from the Nourishing Essence Garden 養素園傳信方, 6 *chüan*,
3. Proofs of Exorcism 祝由錄驗, 4 *chüan*,
4. Collections 集 under the Names of *Nang* and *Lu* 囊露 (herbs), 4 *chüan*,
5. Observations 話 on the *Pên-ts'ao*, 32 *chüan*,
6. A Gathering of Selected Formulas (of the author and others) 串雅, 8 *chüan*,
7. A Report on the Short Names of Certain Herbs 花藥小名錄, 4 *chüan*,
8. The Secrets of Rising and Sinking 升降祕要, 2 *chüan*,
9. Leisure Readings on the Maintenance of the Health 攝生閒覽, 4 *chüan*,
10. Explanations of the Properties of Medicines 藥性元解, 4 *chüan*,
11. References to Strange Medicines 奇藥備考, 6 *chüan*, and
12. Supplement to *Pên-ts'ao kang-mu*, 10 *chüan*.

The twelve titles were published in the book catalogue of the *Pao* 鮑 family, and the manuscripts were circulated. At the end of the *Chia-ch'ing* 嘉慶 era (1796–1821) only the manuscripts of Nos. 6 and 12 survived, and these texts were preserved in the *Hang i lien pao* 杭醫連寶 (The United Treasure of Hangchow Medical Doctors). *Chang Ying-ch'ang* 張應昌 reorganized the material in these two texts, corrected the mistakes, and edited and published them in the middle of the *T'ung-chih* 同治 era (1862–1875). The other ten texts have been lost. The manuscripts of the family are said to have been destroyed about 1860 in the Taiping Rebellion.

Of the two prefaces by *Chao Hsüeh-min* which now accompany his Supplement to the *Pên-ts'ao* *kang-mu*, the second is properly a preface to the Supplement and describes his reasons for writing it. The first is really a preface to the whole collection of Twelve Books on Beneficial Relief, and tells something of the circumstances surrounding the writing of each of the treatises. The author says—

"Of the Twelve Books which I wrote, the manuscripts of two, namely, of the 'Proofs of Exorcism,' and the 'Gathering of Selected Formulas,' were set aside last year to be put on the fire, but the manuscripts were saved by the children. The treatise, 'The Best Works of the Medical World,' was completed a year ago. Once I happened to have a chance to read the books in the library of my neighbor, *Huang Fan-wêng* 黃販翁, in which the collection of books on medicine amounted to more than ten thousand *chüan*, and I compared them with my old collection of confidential papers of the Kiangsu and Fukien authors. I selected from them the formulas which had always proved effective to form a treatise entitled 'Best Works.' It was my experience that the selection was not easy. Some of my relatives and friends happened to test the formulas, and told me of improvements. The treatise was then revised, and enlarged from year to year, and its name was changed to 'Transmitted Trustworthy Formulas.'

"In the spring of the year *i-hai* 乙亥 (1755), *Wang Tzŭ-shih* 汪子師 of Hunan Province paid me a visit and made a short stay in my home. I saw on his desk a volume on exorcism, the formulas of which he was testing. I then borrowed the book and copied it myself, and later secured other manuscripts, those of the *Chang* 張 family, of the *Wan* 萬 family, and of the *Hsieh* 薛 family. I tested some of the formulas from them, removed the false ones, saved the effective ones, and wrote the book, 'Proofs of Exorcism.'

"I was addicted to the reading of books. The daytime was not enough for my study, and I continued it by the burning of fat. I disliked to yawn in the study hall, and so I built a box for the lamp and brought it into the mosquito net in order to carry on my reading at night. After some time the soot from the lamp blackened the beautiful net. In the year *ping-tzŭ* 丙子 (1756) I had eye disease. The disease was so serious that I almost became blind; after six months of sightlessness it was finally cured. For this reason I wrote another book entitled 'Collections under the Names of *Nang* and *Lu*.'[4] . . .

"Someday if I can devote my time to studying the canons on the impulse of the blood, on typhoid, on fever, etc., and can organize the material into treatises, I shall write ten more books. These, together with the two books written by my brother, I shall put into a 'Later Twelve Books from Li-Chi Hall.' The year *kêng-yin* 庚寅 (1770), the second month of spring, the sixth day of the month. *Chao Hsüeh-min, Shu-hsien.*"

The *Huo-hsi lüeh* (Outline of Pyrotechnics) is probably one of the earlier works of *Chao Hsüeh-min*, for the note of commendation appended to it by a reader is dated 1753, more than a decade earlier than the dates (1765 and 1770) which *Chao Hsüeh-min* has himself given his own prefaces to the Supplement to the *Pên-ts'ao kang-mu*. The treatise appears to be one of those collections of notes, or summaries of readings, of which *Chao* says that he accumulated several thousand *chüan*. It shows an acquaintance with the materials of the pyrotechnist, and with their properties and uses, and leads one to believe that its author had handled them himself. It appears to consist essentially of the notes and observations of a skilful worker in the art, addressed to one who is already familiar with the principles. It omits many details. It does not, for example, tell how saltpeter is prepared, but it indicates a true understanding of the unfavorable effect of sea salt which may be present in it as an impurity. It shows an interst in the theoretical basis or explanation of the observed facts. It contains no mention of antimony sulfide which was widely used in eighteenth century European pyrotechnics, and conversely it refers to materials and techniques which had not yet been applied in European practice. Many of its points of interest are discussed in the notes which follow the Translation and Abstract and which are numbered with the same numbers as the paragraphs of the Translation and Abstract to which they refer.

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[4] *Nang* and *Lu* are herbs which are used in the treatment of eye disease.

TRANSLATION AND ABSTRACT

HUO HSI LÜEH 火戲略 *AN OUTLINE OF PYROTECHNICS*

By Chao Hsüeh-min 趙學敏

Extraction of Saltpeter

1. [1a–2a] *Hsiao* 硝 (saltpeter) is produced in salty places (salt marshes). The districts in *Ch'ing-yang* 慶陽 (in Kansu) and in *Ho-pei* 河北 (in Honan Province) and the interior of *Shu* 蜀 (*Ssŭ-ch'uan* 四川 Province) have an abundance of this substance. During the autumn and wintertime the ground is covered with a white material which is swept up with a broom and refined by boiling (its solutions), and *hsiao* is thus obtained. In *Ts'ui Fang's* 崔昉 *Wai-tan* 外丹 (exterior *tan*), and in the *Pên ts'ao* 本草 (Book of Medicines), it is called *yin shih* 陰石 (stone of *yin* 陰). In *Fu hung t'u* 伏汞圖 (Diagrams of Conquering Mercury) of *Hu-kang-tzŭ*, 狐剛子 it is also named *pei ti yüan chu* 北帝元珠 (the primary pearl of the Northern God).

2. *Hsiao* (saltpeter) gets its name, I suppose, from the fact that it is the essence of *T'ai yin* 太陰 (the Grand *yin*, synonym of the moon) and will fly away on meeting fire. At the extremity of *yin* 陰, *yang* 陽 begins to appear. *Hsiao* pertains to *li* 離 (a *kua* 卦, namely ☲, standing for *yin*), and has the property of being able to soften the five metals and to change the seventy-two stones into water.

3. The word *hsiao* means to dissolve (to vanish). It (*hsiao*) must be refined for use as an internal medicine. The same is true for use in making fireworks. It is thought that *hsiao* is formed by the influence of the ethereal essence of the salty sea, since it becomes wet in contact with a humid atmosphere. Dryness is essential for *huo yao* 火藥 (fire powder, black powder). If unpurified [1b] *hsiao* is mistakenly used to make the powder, the charcoal of the powder will become moist very easily during humid weather. The iron filings (in the powder) will be surely rusted from the effect of the *lu ch'i* 鹵氣 (ethereal essence of salt) caused by the wet charcoal. It is unlikely that such a powder can produce any good result in *hua p'ao* 花砲 (flower cannon, flower rocket). Consequently, the *hsiao* must be purified to get rid of the *lu ch'i* (ethereal essence of salt) before it is compounded in the fire-powder.

4. For the method employed in the preparation: *hsiao* is put in a large iron kettle, covered with clear water until the water rises one or two *ts'un* 寸 (inches) above the *hsiao*, two *liang* 兩 (ounces) of water glue (glue solution) is added and the contents is boiled for a period of two incenses (the time needed for burning consecutively two pieces of incense). When the liquor boils, foam may form and, in such case, is skimmed off. Remove from the fire and let the liquor stand until clarified. On the next day the supernatant liquor is decanted off and is replaced by fresh water. About three or five white turnips are then added and the contents boiled for another two incenses. Again, remove from the fire, remove the white turnips, and let the liquor clarify as before. Next morning, replace (the supernatant liquor) with fresh water, add new white turnips, and boil the whole again for two incenses. The *lu ch'i* (ethereal essence of salt) is completely removed by such treatment. The *hsiao* is taken out and dried in the sun light.

5. If one wishes to prepare roasted *hsiao*, good *shao chiu* 燒酒 (distilled spirit, samshoo) is added slowly in the kettle to the purified *hsiao* mentioned above, and the contents is roasted to dryness to get the product. Another method for manufacturing *hsiao* is given in *Shui shu pên fang* 水鼠本方 (Original Methods of Making Water-Mice)*.

Preparation of Sulfur

6. [2a–b] *Huang* 黃 (yellow, sulfur) consists of the essence of pure *yang* 陽 of fire-stone. It is formed by condensing the *ch'i* 氣 (ethereal essence) of the sun. Workers in *Wai tan* (Exterior tan), call it *huang ya* 黃芽 (yellow sprout). It is probable that the essence of the sun (sulfur) acquires its body by the influence of wind and wood. The branches of wood (the element wood, sulfur) grow out sideways. Therefore, when they are mixed with charcoal, the flames shoot out sideways. Wood appears blue, therefore its flame (the flame of sulfur) is also blue).

7. Sulfur of light yellow color is named *k'un lun huang* 崐崙黃 (the yellow of *K'un-lun* 崐崙); that of red color, *shih t'ing chih* 石亭脂 (the fat of *Shih-t'ing*, red sulfur); that of blue color, *tung chieh shih* 冬結石 (winter-frozen-stone); while that which is half white and half black is called *shên ching shih* 神驚石 (stone of shocking spirits). They are produced everywhere, in the East, the West, the South, and the North. The grade for making rocket powder must be of deep yellow color. If the bluish grey material is used, there will be a hazard of explosion due to its uncleanness. If one

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* Water-mice are small fireworks intended for use under water.

wishes to treat it with distilled spirit, do not roast it, but stir it and expose it for drying in the sunlight. If it catches fire on roasting with other ingredients, then by using your mouth spray vinegar onto it to stop the fire. If you wish [2b] to remove the odor, make a hollow chamber in a white turnip, fill the chamber with the pulverized sulfur, put the white turnip, into a heap of burning rice-hulls until it is cooked, and the odor is gone.

8. If you wish to change sulfur into a liquid, fill a bamboo cylinder with your sulfur, bury the cylinder in horse dung for one month and you will get the liquid sulfur. This liquid has the characteristic properties of turning the five metals black, of turning mercury red, of giving a purple color with magnetic stone, of making a disturbance with saltpeter, and of becoming quiet with pig fat. One should understand these properties and be able to utilize the sulfur well.

The Use of Charcoal

9. [2b–3b] Charcoal is the soul 魄 of fire. Fire resides in (the element) wood, and wood comes from (the element) water. Whenever wood dies, it turns black to show that it has returned to its original form. The properties of charcoal are to fly away and to give out light easily. It is used in accordance with its properties. The charcoal which is usually used for the making of powder is that from the extreme ends of fir branches. Other varieties are bamboo shoot charcoal which is violent and spreading, bamboo knot charcoal which is violent and powerful, bamboo root charcoal which is hard and side-bursting, calabash vine charcoal which is quick and side-running, bamboo leaf charcoal which gives a hissing sound, cocoanut [3a] shell charcoal which produces splashing noises, mellon skin charcoal which is quick and violent, eggplant charcoal which makes clear crackling sounds, horn charcoal which is permeable to flame, snake skin charcoal which gives flashing light, and grasshopper charcoal which possesses the property of flying away and running. The quick acting powders have the property of destroying and bursting. Charcoal from glutinous rice can be used to make bird-gun powder. Willow and fir charcoals are the lightest of all and can be used to make powders for *Shou hua* 手花 (hand flowers). *P'ao* 砲 (cannon) using ashes of hemp-stalk (in the powder) produce no noise. If the flinty skin of bamboo is used, plenty of smoke results. Other effects can be produced by applying your knowledge.

10. Charcoal must be prepared by burning (the raw material) until the last trace of smoke is driven off. It is then taken out and put into an earthenware jar which has a tight cover. After cooling it is pulverized to the finest degree for use in powder. This substance is much disposed to become moist, and so it must be burned (prepared) just before use. If too much of it has been made, the unused portion must be wrapped in a piece of paper and put into a jar containing (burnt) lime.

11. If the charcoal has been exposed to moist air, it will be unreliable in its effect upon the slowness and quickness of the finished powder, and also it will make the finished powder fail to burn out (produce) colors and flowers. Furthermore, the iron filings will not be completely melted (if used) with such a charcoal.

12. However, there is a wet method for making powder. For instance, in the preparation of *chu êrh yao* 珠兒藥 (bead powder), saltpeter is boiled with the charcoal and the (resulting) mass is pulverized when it is still moist. In the preparation of *hsüeh têng yao* 雪燈藥 (snow-lantern powder), [3b] camphor is boiled with charcoal and the product is also pulverized while in the moist conditions.

13. Another method is the cast-charcoal dry method. If you want it (the product) to appear as a silvery thread, (the material) is cast with lacquer and dried in the sunlight whereupon the properties of the powder are stabilized. If you want to change its color, you can drop it (into a kettle), roast it, and cast it. It depends upon yourself how much of the subject you can understand.

The Use of Iron Filings

14. [3b–4a] *Sha* 砂 (sand, powdered iron) consists of broken cast iron having grains as large as sand, and hence its name. Its old name was *t'ieh ê* 鉄蛾 (iron ants). It also has another name, *t'ieh hsieh* 鉄屑 (iron filings). Without it, *t'ung hua* 筒花 (cylinder sparks, cylinder flowers, fountains or gerbs) will no longer produce flowers (sparks).

15. It should be prepared at the time when it is used. It can not be stored for a long time because it has a tendency to rust. Once rusted, it will produce no more sparks. Old, broken, cast-iron kettles are usually employed (as the material) for making *sha*. The broken kettles are heated to a red heat in order to remove adhering grease and dirt. After cooling somewhat, they are pulverized in an iron mortar while they are still warm. The product is then sieved and separated into four grades. The fines are called upper *sha;* the coarser ones, medium *sha;* the still coarser grade, coarse *sha;* and the coarsest ones are called large *sha.* [4a] Besides these, there is another kind of *sha* which is known as

needle *sha;* it consists of drillings from the boring out of needles' eyes. After the *sha* is sieved, it is wrapped in paper and put in the lime jar to prevent it from rusting. Powdered iron is not to be touched with the hands, otherwise it becomes sparkless rust. Oil can also spoil powdered iron as it makes it melt into beads without producing sparks when burnt in powder (compositions). Powdered iron, when weighed, is to be handled with a copper spoon to avoid contact with the hands.

16. At the present time, powdered iron is all purchased from *Su-chou* 蘇州 (near Nanking). It should have a glistening lustre like that of tin.

The Match (Fuse)

17. [4a–b] Large match is called double wick match and small match single wick match. All kinds come from *Hui-chou* 徽州 (*An-hui* Province, lower Yangtze valley) (where they are manufactured) for use as open-lead igniters for *hua p'ao* (cannon). However, in fireworks there are still other igniters which are known as piped match. Matches are of two kinds, the slow ones and the quick ones. Quick matches are made with charcoal of calabash, the slow one with charcoal of willow or fir. *T'ao hua* 桃花 (peach flower) paper is used as the wrapping paper and should be treated beforehand with a solution of saltpeter (and dried) in the summer time. [4b] The powder is wrapped in by twisting the paper around it, and burns readily through a crimp.

18. Matches are packed in bundles of 500 pieces each with the two ends of the bundle tied by paper threads. They are stored in a lime jar for use at the time needed.

19. The powder for matches should be loaded on the paper with a match-spoon in order to get it even. The match-spoon is made from a piece of bamboo by cutting the bamboo to a size as small as a scallion leaf and to a length of about one foot in a thin (spoon) shape. When powder is loaded on paper with this spoon, there will be an even distribution of the powder and match of uniform size will thus result.

Use of Piped Match (Abstract)

20. [4b–5b] Piped match is a match enclosed in a paper tube, the tube being about the size of a wheat straw and fireproofed with alum. In a display of fireworks, piped match is used for connecting the different pieces in order to prevent all of the matches, which cross each other, from burning together at one time, so that the display can be shown in systematic order. Furthermore, the fire of the match is enclosed within the tube and is not visible. After the matches have burned, hundreds of flowers of fire appear suddenly, and the display is made much more amusing. The ends of the match are not piped, with the result that the tube, after the match has burned, finds no support for itself and thus drops away.

Treatment of Papers (Abstract)

21. [5b–6b] There are four kinds of papers used in making fireworks, fire-proof paper, inflammable paper, paper for a sharp crackling explosion, and paper for strength. Fire-proof paper is used in making the inner cylinders of fireworks, and is itself made by treating paper with alum solutions. In wrapping fuses, the paper must be inflammable; this result is secured by soaking it in saltpeter solution. For firecrackers the paper must be readily torn into small pieces by the explosion to produce loud, cracking reports with small fragments of paper filling the air. Bamboo or mulberry-bark paper will be suitable for this purpose. For a certain kind of flower cylinder (fountain), the outer layer of the cylinder must be made of strong paper to prevent the bursting of the cylinder, and for this purpose a layer of thick paper or *yüan-shu* 元書 paper is usually used.

22. [6a–8] Dyed paper must not be used in fireworks, because the color is likely to be destroyed by the powder. If color must be applied, the pigments which are used for ordinary painting will produce satisfactory results and will not be changed by contact with the sulfur fumes.

The Containers

23. [6b–7a] Containers are of three different sorts, namely, the clay cylinder, the paper cylinder, and the iron cylinder. For *p'ao* (cannon, firecrackers), only the first two are in use while all of the three are employed in flower cylinders (fountains). The mouth and the bottom of a cannon cylinder are equal in size, but in a fountain cylinder the mouth is small and the bottom is large forming a horn-shaped (or conical) space in between. (The conical container) will direct the force of the powder upward without being itself burst.

24. To test fountain powders there is a simple method for making the container. A small bamboo cylinder is cut off so that one of its ends retains the knot and the other is left open. The powder is packed into the cylinder until it is almost full. The open end is then blocked tightly with a choke of ashes wrapped in paper. [7a] A hole is made through the knot of the other end for inserting a fuse. This method obviously saves the laborous effort of mak-

ing a paper container. However, before packing in the powder, the cylinder must be packed with paper to make an inner horn-shaped (or conical) cavity with the tip (apex) against the knot. This removes the trouble of cracking or side-bursting. If a horn-shape cavity is made in a piece of dry clay and the clay is used (in the place of the paper) for packing the bamboo cylinder, the result will be the same.

The Compounding

25. [7a–8b] The most essential materials used in the compounding (of the powder) are the saltpeter, sulfur, and charcoal which have been discussed in detail previously. Others are auxiliary substances. However, one has to know the art of compounding. For instance, if *hsiung huang* 雄黃 (male yellow, realgar) or *shih huang* 石黃 (stone yellow, orpiment) is used, (the mineral) must be first stirred with *shao chiu* (distilled spirit) and dried in the sunlight. It will give a yellow smoke. If it is used together with saltpeter, the smoke will be very intense with a yellow light which will not be overshadowed by the light of the burning powder. If sulfur, which has an odor, is employed, it must be roasted with vinegar beforehand in order [7b] to remove the odor. By being admixed with *tsao chio kao* 皁角膏 (a fat from the pods of *gleditschia sinensis*), the powder acquires slowness. By being mixed with *fu jung chih* 芙蓉汁 (the juice of lotus flowers), the powder becomes quick acting. Shreds of cotton give a violet light; *t'ung ch'ing* 銅青 (copper green, verdigris, basic acetate of copper) produces a green light; *yin chu* 銀硃 (vermilion, cinnabar), a red light (smoke?); *ch'ien fên* 鉛粉 (lead powder, white lead, carbonate of lead), a white light (smoke?); *hsiung ching* 雄精 (realgar), a yellow light (smoke?); and *sung mei* 松煤 (pine soot), a black light (smoke?). The above contain the five colors of light (smoke?).

26. *Shih huang* 石黃 (orpiment) produces a yellow smoke; *ch'ing tai* 青黛 (lapis lazuli) a green smoke; *chu sha* 硃砂 (cinnabar) a red smoke; *ni fên* 膩粉 (greasy powder, calomel) a white smoke; and *li ch'ing* 瀝青 (pitch, resin) a black smoke. The addition of gold or silver foil makes a light similar to that of gold fragments. The addition of tin foil makes a light resembling that of broken red clouds. Sulfur alone makes it (the light) blue, while the addition of *tan fan* 膽礬 (bluestone, blue vitriol, copper sulfate) makes the light still stronger. Saltpeter alone renders the light violet. *P'i shih* 砒石 (white arsenic, arsenious acid) produces a still longer light (flame). *Shih nao yu* 石腦油 (rock oil, bitumen, asphalt), *chang nao* 樟腦 (camphor), and *ti sou* 地溲 (earth-extract) all can produce fire from water (liquid). The thorns of *gleditschia sinensis*, spring-willow-branches, bamboo shoots etc., all are able to produce something else in the fire. The presence of impurities in the root (the powder) is due to the incomplete extraction of the saltpeter. The feebleness of the flowers (sparks) is caused by the use of unfresh (deteriorated) iron filings.

27. If one wishes the powder to produce fruits, the spraying of water should be so plentiful as to be comparable to that of spring time. If you want the light to be controllable, (the powder) should be stirred with a bath of plums. Earthworm powder and snake skin are used according to their properties. [8a] Boiling in a solution and drying in the sunlight will bring out the efficacy. The persons who are able to do the job will not be limited by a single rule. The followers (students) should be able to derive everything from the above (discussion).

28. The proportions (quantities) must be accurate and the mixing must be thorough. Iron filings are of coarse and fine grades. (The addition of) charcoal has its own order. When the roasting method is used, the ingredients must be roasted separately. If the wet method should be chosen, the procedures would not be the same. The crushing and grinding apparatus should be in good condition and efficient. During the sieving, precautions must be taken with respect to wind and fire. Follow these rules and you will have over one-half of your thought (more than half of the expected results).

The Roasting of Powder

29. [8a–b] In making powder there is an excellent method of combining the advantages of water and fire. For example, *ch'iang yao* 鎗藥 (gunpowder) is made by boiling saltpeter and sulfur with water, roasting (the product) with charcoal and stirring to form the beads. *Huo chiu* 火酒 (fire spirit, alcohol) is sometimes used in the roasting. According to *Shui shu fang* 水鼠方 (Water and Mice Methods) of *Yün ch'i* 雲溪 (Cloud-spring) floating (upper) saltpeter, jumping saltpeter, and settled (bottom) saltpeter are recommended. In *Jên yüan fang* 仁源方 (Spring of Kindness Methods), alcoholic saltpeter is employed to make the five-color butterfly. A certain one roasts (the powder) with oil, lacquer, snake-blood, or juice of *fu jung* 芙蓉 (lotus flowers). Again, another roasts in the dry state or roasts with addition of other substances. Probably, the advantage of dry roasting is to absorb the power of fire for assisting the rising property (of the powder), while that of admixing with other substances is to make use of the power of

those substances to conform to the will of the *shên ming* 神明 (spirits).

30. There is no definite method. If you want to minimize the yellow flame, *tan fan* 胆礬 (bluestone) will be mixed in. If you want to retain the light of saltpeter, (the powder) is to be boiled with rosin oil. If you want the powder whirling around, tails of grubs will be added during the roasting. If you want the powder to be spreading, earthworm blood will be added during the roasting. When silver foil is roasted for use in powder, ash of lotus leaves is to be added. When copper foil is roasted for use in powder, walnut ashes are to be incorporated. The reason is for controlling (the effect).

Miscellaneous Substances (Abstract)

31. [8b–10a] Common people know only that substances which are inflammable can be incorporated into fire powder. However, the non-inflammable materials, when used properly, produce wonderful results. This has been stated in the Books of *Tan*, that all substances can produce light. It is the substance of inflammable material and the spirit of non-inflammable which are effective. For instance, minerals such as *huang tan* 黃丹 (minium, red lead oxide), *mi t'o sêng* 蜜陀僧 (litharge) and *hei hsi hui* 黑錫灰 (black tin ash, lead), all are heavy and are able to suppress the power of the powder. *Ku ch'ing ch'ien* 古青錢 (old copper coins, old brass), *t'ieh hua fên* 鉄華粉 (acetate of iron) and silver rust are able to split fire to give flowers. *Lu kan shih* 爐甘石 (zinc bloom, zinc carbonate), *pu hui mu* 不灰木 (non-ashing wood, asbestos) and *shih chih kao* 石脂膏 (stone fat, siliceous clay) can be used to treat paper and to separate fire. *Ch'ing fên* 輕粉 (calomel), *chung ju* 鍾乳 (stalacitites, chiefly calcite), and *shih t'an* 石炭 (graphite) are able in certain cases to produce particular effects. *Yü shih* 礜石 (arsenolite, white arsenical ore), *huang fan* 黃礬 (yellow-colored alum), and *lei mo* 雷墨 (meteorites) all are able to invert the light. *Nao sha* 硇砂 (sal ammoniac), *p'êng sha* 蓬砂 (borax), and salt assist saltpeter and sulfur in the powder to burn out.

32. As for vegetable materials, (the charcoal of) rush stalks can change a small fire into a large one. Rosin can concentrate spreading light into spot light. (Numerous other effects of various vegetables and animal materials are also mentioned).

The Use of Powders (Abstract)

33. [10a–11a] If you want the piece to fly, the addition of mice-powder is necessary. If you want it bright, moon-lantern-powder should be added. Powders for filling soft containers are usually fine and are not quick-acting. If quick-acting powder is used (in this case), the container will be shattered and your hand may be injured. The flowers of soft pieces must shoot out sidewise and open slantingly, otherwise the choke will be blasted out and random burning result from the straight-upward shooting. With a large proportion of saltpeter, the force of the powder is tremendous. With plenty of charcoal, the light of the powder becomes scattering. Powders rich in sulfur make loud sounds, while those rich in powdered iron give obscure (unclear) flowers. The shaking of the container (unevenness of firing) is caused by the formation of obstructions in the mouth. The formation of beads on top of the flowers is caused by the use of rusted iron filings.

The Coatings and Pastes

34. [11a–b] It is necessary to know the use of coatings and pastes, for, by means of these, results from the powder are made much more wonderful and changeable. They are comparable to the color designs of a painter and to the pattern designs of a textile-maker. If a powder does not have a coating or paste, it will not be able to trace out its flight, and the weak and intense colors are not to be distinguished. It will also fail to concentrate the light, and the wonders of the changes will not be magnificent. This subject, therefore, ought to be discussed.

35. Whenever the grains of a powder have no particular shapes, the grains are called beads. Those which have corners, are called prisms. They may have the shape of grain-awns, chelae, hair, the scars of the moon, a broken wall, a broken sword, fractured calcite, or a heap of hooks. They may contain eight corners, a trident, a conical shape, or a shape of a bowl-head.

36. Some of these grains are shaped (molded) with open fire, with greenish fire, with explosion-powder, or with ignition-powder. It has been stated that powders which have a shape, can put on clothes. Red clothes (coating) consists of *chu sha* 硃砂 (cinnabar); green coating, of sulfur; blue coatings, of *t'ung lü* 銅綠 (verdigris, green copper); white coating, of *ch'ien fên* 鉛粉 (lead powder, white lead); and coatings of other colors will be made up in a comparable manner.

37. Some people use a paste. For example, when cotton is coated with a sulfur paste, (and is used in the powder), the fire with purple-green balls will fly out. When tin foil treated with a saltpeter-sulfur paste is used, one can see the fire spitting out colored light (flames). If wick-grass is used in the powder, the paste-method must be applied. Some-

times powdered iron is also coated or pasted. When this is used in fountains, the flowers are much more deceptive and marvelous. Again, some one uses powder to coat upon the coat, a paste upon the coat, one side with coat while the other with paste, or coating and paste in the center. In another method, the grains of the powder are dressed (coated), made into shape, wrapped together, and coated again. This is called the seven-star coating. The method of using one layer of coating, then one layer of powder, and so on, layer after layer, is called case-coating. Sometimes, the pipe of a piped match is also coated or pasted. This kind of trick is not understood by those who have not specialized in the art.

The Packing in of the Powder (Abstract)

38. [12a–b] To save labor, the powder for firecrackers is loaded into 300–500 small, colored cylinders at one time, all of the cylinders being made up into an hexagonal bundle with the openings facing upward, and the powder is then run in from a long spoon (funnel). In packing fountains, the powder, after loading, must be stirred to prevent the settling down of the powdered iron, and is not to be shaken, otherwise, the ingredients will be separated from each other with the charcoal on top, and the saltpeter and sulfur at the bottom. The powder for crackers must be packed loosely but the powder for fountains is pressed hard.

Auxiliary Shows (Special Pieces) (Abstract)

39. [12b–13b] The Hundred Sons, The Three Ranks, The First of All, Lucky Clouds, Butterflies, Rockets, Flowers of the Moon, Brick Flowers, The Nine Dragons, the Eight *Hsien* 仙 (immortals), etc., are auxiliary shows (special pieces). They may be fired singly or may make up a part of a play. They go up in the air, jump on the ground, and fly to the one side or dance on the other. These furnish motions in front of a stationary spectacle. Rockets are the eyes of fireworks, and are fired before the main display in order to quieten the audience.

40. There are some fireworks for display in the day time. They are called smoke-plays, and make use of smokes. They may be so constructed as to display colored buildings, towers, human beings, mountains, waters, and various spectacles. The auxiliary shows (special pieces) may be earth mice (ground mice), water mice, snow crackers, smoke crackers, incense lanterns, falling pearls, smoke horns, foggy orchids (orchids of mist or smoke), colored wheels, colored wings, etc., while colored rockets are used as the first fire. The flower shells are shells filled with powder for enlarging the shows and are to be reckoned as special pieces. Shells of fruits, nuts, fir cones, calabash, paper, clay, wood, etc., are also used.

Flexible Pieces (Abstract)

41. [13b–14b] Flexible articles are constructed by using folding frames on which images of men and other things, buildings, towers, etc., can be mounted at will to form a spectacle. The frames are made of bamboo, hemp-rope, and paper. There are self-illuminated figures and figures to be illuminated. Fire wheels, fountains, crackers, rockets, flower-moons, flying rats, etc., may also be mounted on the same frames. Fireproof materials are always procured by treating with alum solutions.

Fireproof Screens (Abstract)

42. [14b–15b] When three or four spectacles or displays are mounted and folded up into one package, the bottom spectacle must be separated from the upper one by means of a screen of fireproof paper in order to prevent them from burning together. After the display has been exhibited, the screen is dropped off automatically. If alum alone is not sufficient to make the paper fire-proof, *lu kan shih* 爐甘石 (zinc bloom, zinc carbonate), *shih chih fên* 石脂粉 (fuller's earth) or lime may also be used in combination with it.

Head Fuses (Abstract)

43. [15b–16a] If a fire show is lighted at the bottom, the fire goes upward slowly. The difficulty is reduced by lighting it at the top also, so that it takes fire all over. This is done by means of head fuse or top match.

Rigid Pieces (Abstract)

44. [16b–17a] A rigid piece is used when there is only a single spectacle which does not need to be folded up.

Changing Shows or Transformations (Abstract)

45. [17a–b] The appearance of one thing which will change into another in a show, is called a changing show or transformation. Examples are: a fish changing into a dragon, a copper coin changing into a butterfly, the two *hsien* (immortals) giving *tao* 道, the two dragons playing with the ocean (the latter two items have two things change into one), the flat peach, and the god of longevity, and others.

Multiple Pieces (Abstract)

46. [17b–18a] In fireworks displays two or more sets of articles are sometimes fired separately and at

the same time in adjacent scenes to make up one spectacle. They are called combinations.

Flying Pieces (Abstract)

47. [18a–b] *Liu hsing* 流星 (flying star, rocket), flying rat, flower-moon, etc. are the small flying pieces. In plays, for instance, the *hsien*-people (immortals) hailing the crane, the envoy *Hsiao* 蕭 riding on the phoenix's back, the golden lotus bursting out from the ground, the five old men going back to heaven, etc. are the flying articles of larger designs.

Water Fireworks (Abstract)

48. [19a] Powder is put in pig's intestines, paper swans, bamboo cylinders, etc. to make fireworks which are fired on the surface of water. Colored smokes and water-mice are fired under the water.

Moving Pieces for Banquets (Abstract)

49. [19a–b] Small articles such as jumping grasshoppers, wandering fish, running snakes, galloping deer, etc., all of these being small pieces about an inch in length, are fired after a banquet. It is supposed that their smoke facilitates recovery from over-indulgence.

Folding Frames (Abstract)

50. [19b–20a] Folding frames in the form of leaves are made of iron wires. They can be folded over for the mounting of fireworks.

Assembling the Display (Abstract)

51. [20a–b] Pieces are fastened onto the frame with bamboo fibers or paper-wrapped iron wires, but not with hemp rope, for the latter slips.

Connections (Abstract)

52. [20b–21b] There are internal connections and external connections. The internal ones use powder while the external ones use match.

TABOOS

53. [22a] Essentially, no precautions are needed in the use of *huo hsi* 火戲 (fire-plays, fireworks), but, because of their violent character and light producing ability, wherein they resemble the sunshine on all the devils, they are not to be treated carelessly. Although *ni yün* 尼褌 (woolen cloth) and *ching pu* 經布 (muslin) can stop the shooting of a candle, and iron shots and magnetic stones are able to control sulfur, these are the specific properties of the substances, but human actions also accomplish their effects.

54. The compounding must not be done in a family which is in mourning. It is especially prohibited in the house where a funeral has been held or where a man has died, for there the misfortune of accidental fire is certain to happen.[5] In case the mourning is for someone outside of the immediate family, and in case the family wishes to buy powder and must use it, a piece of red silk-cloth may be hung in the compounding room to release (the family) from the prohibition of using powder. In a house where fireworks are being made, one must not burn *ts'an sha* 蠶沙 (grass?) or bamboo leaves lest by this means the essence of the saltpeter is weakened.

55. During the packing of powder, if a drum is beaten to strike power into the powder, the fire-flowers will be brighter. However, during the compounding, the sound of a drum must not be heard lest the powder in consequence acquire the defect of bursting. The ashes on the charcoal must be removed before use. If [22b] a charcoal with adhering ashes is used, the resulting powder will usually be impeded. Probably the ashes are the ghosts of charcoal and the charcoal is afraid of them.

56. Women are not allowed to handle the powder. If the powder is packed by women, the crackers will change into fountains and vice versa. Smoking is forbidden in the powder room. The room should be kept quiet and neat, and noisy talk forbidden in order that the soul of the powder may be soothed. Care must be taken to prevent any changes in the powder. The testing of powder must not be carried out at any place near the powder house. The filling of the cylinders must not be done near any fire or smoke. The apparatus for handling the powder must be closed tightly, and the access of wind must be prevented. After long standing in the wind, the powder takes fire spontaneously. Artifices after being loaded with powder, must not be heated again (for drying), for there is danger that the powder may show its behavior spontaneously after long-continued warming. The tamping or pounding of the powder must be neither too heavy nor too light, and the amount of the powder may not freely be increased or decreased. The packing of powder by lamplight is not permissible. The opening of the powder container on a rainy day is not permissible. Those who hold established formulas will be limited by them; who understands elemental changes?

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[5] Fireworks, especially crackers, are used in China solely for celebrations or for the purpose of expressing joy, and are avoided in times of sadness. They are supposed to have the power of driving devils away.

Skill of Craftsmanship (Abstract)

57. [22b] The various operations, the fastening of the artifices, the connecting of the fuses, the preparation of the powder, the tamping in of the charges, etc., all require special tricks of manipulation.

The Spare Pole (Abstract)

58. [23b] A stick or pole is useful in case some of the hanging pieces misfire or burn improperly.

A NOTE ON READING THE TREATISE HUO HSI LÜEH

By *Yang Fu-chi* 楊復吉

[24a] An account of fireworks has rarely been published. The only available information appears in *Yüeh ling kuang i* 月令廣義 (The *Yüeh-ling* Expanded, by *Fêng Ying-ching:* 馮應京) and in *Wan shu chih* 宛署記 (Memoranda of *Wan-shu*), both of which were written in the *Ming* 明 dynasty. These contain only a few words (on fireworks), and are of little use. *Chao Hsüeh-min* 趙學敏 of *Ch'ien-t'ang* 錢塘, giving himself to relating in detail the formulas for manufacturing fireworks, has prepared a book. Although the subject is trifling, much energy and patience has gone into the collecting and assembling of materials. The work really occupies a place which has never before been filled. By no means should we laugh a bit at this composition as useless. *Yang Fu-chi* of *Chên-tsê* 震澤, in the late summer of the year *kuei-yu* 癸酉 (1753).

NOTES

1. *Chao's* description of the purification of saltpeter is so incomplete that one is tempted to infer that he had had no experience with the process. No effort appears to have been made to supply the deficiency of potassium in the crude material, or to replace the calcium which is commonly present, as is done in Europe by the use of wood ashes.

2. It is interesting to find that saltpeter, the oxidizing agent, is related in Chinese chemistry of the eighteenth century to the negative principle, *yin*, as oxygen in Europe was considered to be dephlogisticated air, and that sulfur in China was the embodiment of the positive principle, phlogiston, the essence of pure *yang*.

3. Unpurified saltpeter containing sea salt is more hygroscopic than the purified material. Impure saltpeter encourages charcoal (with which it is mixed) to take up moisture, and iron filings to rust.

4. The clarification by means of glue would work. White turnips boiled in the solution of impure saltpeter would absorb a certain amount of the dissolved salts, and conceivably might, as the text suggests, remove the chlorides faster than the nitrates—but we have no information on this point.

8. The process which is here described for the preparation of liquid sulfur might well yield a solution of ammonium polysulfide which would have several of the characteristic properties of sulfur. It would, for example, blacken the common metals including mercury, and would also convert mercury into cinnabar by suitable manipulation. The other reactions which are enumerated are not so evident, the purple color with magnetic stone and the disturbance with saltpeter, for ammonium polysulfide solution does not react with saltpeter. With pig fat it would emulsify to form a salve or ointment.

10. Charcoal is hygroscopic. *Chao* recommends that it be kept, as we would say, "in a desiccator over lime."

11. Charcoal which has taken up water makes the compositions which contain it unreliable in their performance.

12. The wet method of making black powder, particular sulfurless gunpowder, is at present in use in this country. The text apparently refers to sulfurless gunpowder. Particles of charcoal impregnated with camphor (snow-lantern-powder) would produce an interesting effect when used in gerbs or fountains.

13. The powder is mixed with lacquer and cast; the resulting mass is not affected by moisture, and is stable in its properties. No analogous method was in use in Europe.

14, 15. Powdered cast iron and steel dust were used in Europe at this time, and mixtures containing powdered cast iron were generally called Chinese fire. Lieutenant Robert Jones, contemporary with *Chao*, reports the following formulas.

"For a Brilliant Fire. Meal powder twelve pound, saltpeter one pound, brimstone four ounces, and steel dust one pound and a half.

"Chinese Fire. Saltpeter twelve ounces, meal powder two pound, brimstone one pound two ounces, and beat iron twelve ounces.

"For Gerbes. Meal powder six pound, and beat iron two pound one ounce and a half."[6] The same author gives six compositions "for standing or fixed cases" (fountains) of which two contain steel dust. Needle steel (drillings from the manufacture of needles) are used in gerbs in this country at present.

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[6] Jones, "Artificial Fire-Works, Improved to the Modern Practice, From the Minutest to the Highest Branches," etc., 2nd ed., London, 1766, pp. 43, 44.

Cutbush states that "D'Incarville, a missionary at Pekin, obtained the process for making Chinese fire; and observes, that the pulverized cast iron they employ is called *iron-sand*, of which they have six numbers or varieties.[7] . . .

"The Chinese have long been in possession of a method of rendering fire brilliant, and variegated in its colours. Cast-iron, reduced to a powder more or less fine, is called iron-sand, because it answers to the name given to it by the Chinese. They use old iron pots, which they pulverize, till the grains are not larger than radish seed; and these they separate into sizes or numbers, for particular purposes."[8]

Chao's text indicates a real understanding of the properties of powdered iron, and mentions several wise precautions to be exercised in its handling. The practice of wrapping the powder in paper and keeping in a desiccator over lime is a good one, but it does not guarantee the keeping qualities of the mixtures in which the iron is subsequently used. Cutbush however recommends a somewhat similar method of storage. "As the goodness of iron or steel dust, in fire-works, depends greatly on its being dry, and not oxidized or rusted; its preservation must be accordingly attended to. The usual preservative is to put it in a box, lined with oiled paper, and covered with the same, or in tin cannisters, with their mouths well closed.[9] . . .

"It should be observed, that rockets, into the composition of which, iron-filings and iron-sand enter, cannot be long preserved, owing to the change which the iron undergoes in consequence of moisture."[10]

On the subject of preserving steel and iron filings, Jones says—"It sometimes may happen, that fireworks may be required to be kept a long time, or sent abroad; neither of which could be done with brilliant fires, if made with filings unprepared; for this reason, that the saltpeter being of a damp nature, it causes the iron to rust, the consequence of which is, that when the works are fired, there will appear but very few brilliant sparks, but instead of them a number of red and drossy sparks, and besides, the charge will be so much weakened, that if this should happen to wheels, the fire will hardly be strong enough to force them round; but to prevent such accidents, prepare your filings after the following manner."[11] He then describes the process of coating the filings with sulfur by stirring them up with melted brimstone. This method was commonly used in Europe as late as the first half of the nineteenth century, but it is more usual now to coat the filings with beeswax, paraffin, or linseed oil.

17. Different kinds of charcoal for quick and for slow match.

18. The match is kept dry by means of lime.

20. The trick of leaving the ends of the match unpiped, and thus of causing the match tube or pipe to fall away from the piece after the match has burned, is one which does not appear to have been used in Europe. The piped match burns almost instantaneously, but the portion of the match which is not enclosed within the tube burns slowly.

21. The use of alum for fireproofing was ancient and widespread. Archelaos, one of the generals of Mithradates in the war with Rome in 87 B. C. fireproofed a wooden tower by means of alum, and the wooden siege engines which the Romans used in the war of Constantine and the Persians in 296 A. D. were similarly treated.[12]

22. Many kinds of dyed paper are bleached by the sulfur which is used in the compositions, but the common pigments are generally not affected.

23, 24. The Chinese technique in the making of fountains is described. The conical shape of the interior of the container provides what amounts to the choke or constricted exit for the gases in European practice.

25. Orpiment and realgar, sulfides of arsenic which occur naturally as minerals, were used in European compositions at an early date. They are combustible and burn with a bright, white light. They are also volatile, and yield yellow smokes to the extent that they escape combustion. The intent of the statement that shreds of cotton give violet light is not clear. Verdigris does impart a greenish or bluish color to the flame, especially if chlorides are present; lead compounds tend to give a lilac color; but black *light* from pine soot is obviously impossible. It is probable that the word, light, applied to the effects of verdigris, vermilion, white lead, and pine soot, is in error and that the appearance, like a smoke puff, of a cloud of the finely powdered material, blown about by the force of the burning composition, is really intended.

26. The lapis lazuli, cinnabar, and calomel are evidently intended to be used in the state of fine powders to produce colored clouds of dust, and the

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[7] James Cutbush, "A System of Pyrotechny, Comprehending the Theory and Practice," etc., Philadelphia, 1825, p. 202.

[8] *Ibid.*, p. 371.

[9] Cutbush, *op. cit.*, p. 202.

[10] *Ibid.*, pp. 371–372.

[11] Jones, *op. cit.*, p. 83.

[12] Partington, "Origins and Development of Applied Chemistry", London, New York, Toronto, 1935, p. 148.

metal foils, gold, silver, and tin, to be blown out in the same way as the colored powders to produce interesting visual effects. Pitch burns to produce soot or black smoke. Calomel is volatile and will produce a white smoke; it is used occasionally at present, particularly in blue lights, to supply chlorine which enhances the blue color which copper compounds give to the flame. Potassium nitrate (saltpeter) mixed with combustible materials gives a violet flame, sodium nitrate a yellow one.

29. The wet method of making black powder is described, and explanations given of the effects of dry roasting and of wet roasting with the admixture of other substances.

30. A copper compound to reduce the yellowness of the flame. If the powder is boiled with rosin oil (possibly turpentine), its flame will be smaller in size but more lasting in time.

31. There are certain incombustible substances which are useful in the pyrotechnic art for the production of various effects.

32. Rosin can "concentrate spreading light into spot light" by preventing an explosive expansion of the mixture in which it is incorporated.

33. Mice-powder and moon-lantern-powder are special powders for use in particular fireworks. The author makes practical observations which suggest that he has had an extensive experience with pyrotechnics; he mentions the effects of the saltpeter, of the sulfur, of the charcoal, of the iron sand, etc., and the fact that obstructions in the choke cause the piece to shake or to jump about.

34–37. The coated and composite grains evidently represent a technique of Chinese origin and indicate that certain of the effects of the fireworks are intended to be observed in the daytime. The burning grains of powder trace out their flight both by their flame and by their smoke. A compact mass or grain of burning composition, thrown out from a rocket, Roman candle, gerb, fountain, or flower pot, is called a *star* in our present practice. Composite stars are made in this country in such manner that the stars change color while they are burning or that the single stars burst into several stars of the same or of different colors. But daylight fireworks have not been popular, and we have not known of stars being coated with materials which produce colored smokes as is described in the Chinese text. The use of iron sand would produce an effect similar to that of penny sparklers or of electric spreader stars.

38. It is a good practical observation that the powder for crackers must be packed loosely but that the powder for fountains is pressed hard. The hard-pressed mixture burns from its surface; the flame from the burning cannot penetrate into its mass. If it were loosely packed, like granular gunpowder, the mixture would burn rapidly throughout its mass and an explosion would result. The tendency of mixtures containing iron sand to lose their uniformity is also correctly noted. These mixtures must be stirred constantly while they are being loaded and then pressed, tamped, or pounded so firmly into place that they can no longer separate.

39. The Chinese names for the various pieces of fireworks are no more bizarre and fantastic than those which are used in this country. Recent American catalogues list such pieces as "jeweled cascade," "devil among the tailors," "golden sunrise," "whistling pigeon," "wheel of fortune," "illuminated surprise," "yellowstone wonders," "fountain of youth," "jack in the box," "horn of plenty," "diamond necklace," "Hawaiian frolic," "dance of the fairies," and "messenger to Mars."

42. The fireproofing of paper with alum, or, if this is insufficient, by the use of an additional dusting with zinc carbonate, fuller's earth, or lime.

54. Sympathetic magic: the bad effects upon the powder of mourning, death, funerals, etc., but, if the mourning is for someone outside of the immediate family, then its effect may be counteracted by magical means.

55. Magical effects on the powder of the beating of a drum. Wood ashes mixed into the powder make it burn more slowly.

56. An intermingling here of magic with sound good sense: several sage precautions to be observed in the handling or powder are mentioned. The statement that the powder takes fire spontaneously after long standing in the wind appears to be in error, but may perhaps contain a certain element of truth. The several components of the powder, differing in density, would be more or less separated by the wind, and the blowing about and settling of the dust would introduce new hazards which might result in easy, if not actually spontaneous, ignition.

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NEW RESEARCHES ON MAGNETIZATION BY ROTATION AND THE GYROMAGNETIC RATIOS OF FERROMAGNETIC SUBSTANCES

By S. J. Barnett

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1. Introduction. Since 1914, when the first gyromagnetic effect to be observed was discovered,[1] by a method of electromagnetic induction, many researches have been made on the gyromagnetic ratios of magnetic substances. In the case of ferromagnetic substances, successful measurements of this ratio (i. e. the ratio of the angular momentum of the magnetic element to its magnetic moment) have been made by investigating two different, but closely related effects, viz: (1) *magnetization by rotation*, or the *Barnett effect;* and (2) *rotation by magnetization*, or the *Einstein-de Haas effect.*

Much the most extensive measurements have been made in my own laboratories, in two series, as follows: one series (I) by means of my own effect (1920–1925),[2, 3] the other series (II) by means of the Einstein-de Haas effect (1925–1939).[3] The results of the two investigations agree, for the most part, very well; but those of the second are much the more precise, partly because the sources of error in working with the Einstein-de Haas effect, while themselves quite difficult to eliminate thoroughly, are not so difficult to eliminate as are those encountered in working with the other effect. The evidence appears to show definitely that the results of Series II are the most precise which have hitherto been obtained.

On account of such discrepancies as exist between the results of Series I and Series II it has long seemed important to make a new and independent investigation of the rotors used in Series I by means of the same effect, even if increased precision should be impracticable to attain. The first part of such an investigation is described in this paper. Fortunately, for most of the rotors, the precision has already been considerably increased over that of Series I.

At the same time it is important to study the various methods of investigation further with the hope of increasing the precision. For the pure magnetic metals and alloys to which my own work has been restricted, the values of the gyromagnetic ratio extend through only the small range from about m/e x 1.00 to about m/e x 1.08 or 1.09, and only two of them are known to less than one per cent. Furthermore, as Professor Pierre Weiss remarked to me at the Strasbourg *Réunion*,[3] the work "must be extended to more substances and to the same substances in different states; and for this purpose it is necessary to increase the precision."

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[1] Ohio Academy of Sciences and American Physical Society, November and December, 1914. See S. J. Barnett, *Magnetization by rotation*, Phys. Review 6: 239–270, 1915.

[2] S. J. and L. J. H. Barnett, Proc. Amer. Acad. 60: 127–216, 1925.

[3] See especially S. J. Barnett, *Gyromagnetic ratios for ferromagnetic substances: New determinations and a new discussion of earlier determinations.* Proc. Amer. Acad. 73, 401–455, 1940. See also a briefer discussion in the reports of the *Reunion d'Études sur le Magnetisme*, held at Strasbourg under the presidency of P. Weiss in 1939. These reports were published in Paris by the *Institut International de Cooperation Intellectuelle* and the *Service Central de la Récherche*

Series I was made by a magnetometer method in a building free from iron, a part of the plant of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, where the magnetometer could be controlled without too great difficulty. Experience in the Norman Bridge Laboratory, which is full of iron, involving the use of a magnetometer in another investigation,[4] convinced me that in this laboratory the method of electromagnetic induction would be preferable, if it could be made sufficiently sensitive, on account of the superior degree of freedom from asymmetry—the source of most of the errors—which it makes possible. At the same time it offers the great advantage over the magnetometer method that in it provision can far more readily be made to measure only changes of magnetization instead of magnetization itself. Furthermore, for the sake of a greater degree of independence, it was desirable to adopt a method radically different from that used in Washington.

The new work is still far from complete, progress having been greatly interfered with by the defense and war situations. While it is certain that the work can be greatly improved in many particulars, nevertheless a degree of precision at first hardly hoped for by the method of investigation here adopted has already been achieved in this preliminary work, and important independent confirmations of earlier work obtained. For this reason, and because the investigation cannot probably be greatly advanced until after the war is over, publication of the work already accomplished is being made at this time.

2. PRINCIPAL SOURCES OF ERROR ASSOCIATED WITH THE ROTATION IN THE METHOD OF ELECTROMAGNETIC INDUCTION. Most of the sources of error so far discovered in the study of magnetization by rotation, together with methods designed to eliminate them, are discussed in the earlier papers. Some of these will be treated further, and others will be discussed, in this paper. The sources of error directly associated with the rotation may be divided into two classes as follows:

A. *Sources independent of the rotor's magnetization*, viz.: (1) eddy currents arising from incomplete compensation of the earth's magnetic field, (2) electric currents produced by thermal effects at the bearings and by air driven by the moving rotor against the adjacent parts of the apparatus, (3) electrical or magnetic effects in the motor and other driving apparatus and auxiliary apparatus.

B. *Sources dependent on the rotor's magnetization*, viz.: (1) torsion of the rotor, driven from one end and moving with friction in a bearing at the other, (2) thermal effects on the rotor due to friction at the bearings and to air currents, (3) centrifugal expansion, and other strains, produced by the rotation and perhaps by gravitation, (4) axial displacement of the rotor produced by the rotation, (5) displacement of the rotor in altitude or azimuth, or distortion, in the incompletely compensated magnetic field of the earth, (6) non-uniform initial position-angle setting of the rotor, (7) vibration.

3. THE METHOD OF ELECTROMAGNETIC INDUCTION AS APPLIED TO THE STUDY OF MAGNETIZATION BY ROTATION. In the method of electromagnetic induction a coaxial coil of insulated wire surrounds the rod under investigation and is connected in circuit with a galvanometer of the fluxmeter type. If the magnetic moment of the rotor is changed by any small amount the fluxmeter gives a deflection proportional thereto. In the main experiment the angular velocity of the rotor is changed by the amount $\delta\Omega$ and a change of magnetic moment δM results, producing a deflection D of the fluxmeter. In a calibrating experiment a minute axial magnetic intensity is applied to the rotor and is altered by an amount δH. This produces a change $\delta M'$ in the moment, which causes a deflection Δ of the fluxmeter. The quantities δM and $\delta M'$ are proportional, respectively, to the change $\rho\delta\Omega$ (where ρ is the gyromagnetic ratio of the magnetic element) in the intrinsic magnetic intensity of rotation and the change δH in the intensity of the axial field. Thus we have

$$\frac{\delta M}{\delta M'} = \frac{\rho\delta\Omega}{\delta H} = \frac{D}{\Delta}$$

whence

$$\rho = \frac{D}{\Delta} \cdot \frac{\delta H}{\rho\Omega} \quad . \; . \; . \; . \quad (3\text{—}1)$$

In the actual earlier experiments by this method *two similar* rods were mounted with their axes horizontal and normal to the magnetic meridian, and *two similar* coils of insulated copper

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Scientifique de France, under whose auspices the *Réunion* was held, but their general distribution has hitherto been prevented by the war.

[4] Proc. Amer. Acad. 68: 229, 1933.

wire were mounted symmetrically about their centers, as shown in Fig. 3—1. These coils were placed in series with one another and with the fluxmeter and were oppositely connected so that any fluctuations in the intensity of the earth's magnetic field, which act in the same way on both rods, might produce no effect on the fluxmeter. One of the rods, the *compensator*, A, remained at rest; while the other, the *rotor*, B, was alternately rotated in opposite directions, the change in its magnetization being determined as it came to rest or to very low speed. For use in the standardizing experiments the rods A and B were uniformly wound with single layer coils of insulated copper wire; and two long wooden rods

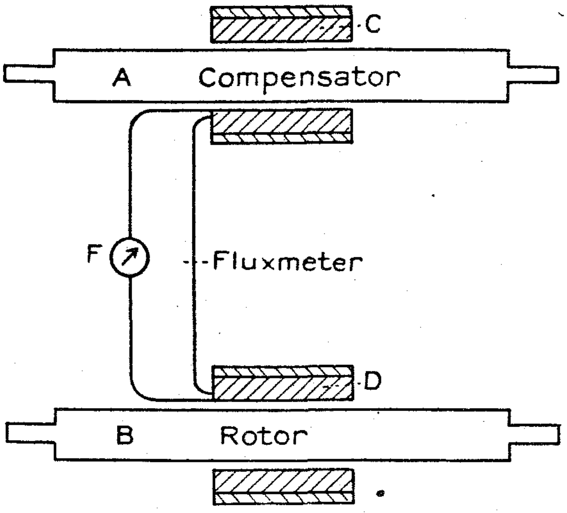

FIGURE 3–1.

of the same diameter and similarly wound were provided for attachment to the ends of the rotor, in order to make reductions to a strictly uniform field. The earth's field, in the region occupied by the rotor, was, in general, neutralized in order to prevent eddy currents and changes in its axial flux due to alterations in the shape or position of the rod, including possible slight alterations of axial orientation caused by the rotation. In alternate runs the rotor was rotated in opposite directions at the same speed in order to eliminate the effects of changes of magnetization due to centrifugal expansion and other disturbing effects. To eliminate the effects of torsion, observations were made for the two orientations of the rotor's axis, 180° apart. The mean result is free from torsional error if the frictional torques at the two ends of the rotor are exactly identical. Unless the bearings and journals at the two ends are exactly similar, complete elimination of the error would necessitate that the bearings also be reversed—a precaution not taken in any of the work; and if the centrifugal thrusts on the bearings due to axial asymmetry of the rotor are different at the two ends, complete elimination of the error would necessitate also that the rotor be driven alternately from the two ends, instead of only from one end, with a single motor. This precaution has been taken only in a part of the new work. Such interchange of motors may help, furthermore, to eliminate the possible error due to differential longitudinal shift of a rotor on reversal of its direction of rotation.

4. MECHANICAL ARRANGEMENTS IN THE NEW WORK WITH ROTOR AXIS HORIZONTAL AND ROTOR AXIS VERTICAL. In the greater part of the new work the rotor, compensator, etc. were mounted with axes horizontal, as in all the work done hitherto. In the remainder of the work the axis of rotation was vertical.

In all the earlier work the rotor was always directly driven by a single countershaft, or a series of countershafts, permanently located either east or west of it. To eliminate certain errors, especially that due to torsion, it was therefore necessary to reverse the rotor's azimuth periodically—a not very troublesome operation, but one requiring time and introducing some uncertainty because of the possible changes in the rotor's magnetization incurred in the process.

Primarily in order to effect the same elimination, in that part of the present work in which the rotor was mounted with the axis horizontal, it was located symmetrically between two exactly similar motors at equal distances, and was driven at will by either one through a series of four countershafts. The motors are of the synchronous type and were always driven at the same speed, viz. 60 r. p. s. In general equal numbers of observations were made with the two motors.

The countershafts were simple bakelite tubes of various sorts, with internal diameter one-half inch and walls one-sixteenth, three thirty-seconds and one-eighth inch thick. They ranged in length from about one foot to about two feet. Each of the tubes nearest the rotor was provided with a brass terminal piece centrally drilled to fit the rotor journals. It was attached to the tube by two similar screws at opposite ends of a diameter, and to the rotor by a set-screw and nut, with a counterbalance on the other side. The terminal pieces used in much of the work ended in circular flanges which were drilled with sixteen holes uniformly spaced around the edge, to serve as position angle indicators. The other end of the tube, in the earlier part of the work, slipped over a half-inch journal, to which it was fastened with small screws when in operation.

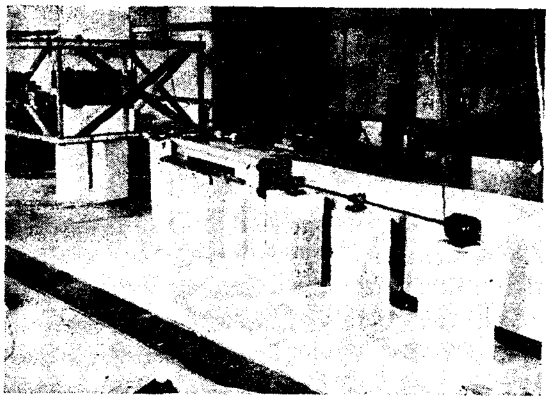

FIGURE 4–1. When this photograph was taken the west motor etc. had been removed to make room for the vertical drips arrangements, which are shown in place on the left.

This journal was part of a bronze thrust bearing permitting only very slight longitudinal motion. When the screws were removed, the tube could be slipped farther on to the journal, freeing the rotor entirely from the tube. In later work, in order to reduce longitudinal play still further, each of these cylindrical thrust bearings was replaced by a combination ball and cylinder bearing. Only one of these ball and cylinder bearings was used with vertical drive. The cylinder was of bronze. The balls and rings were of steel, but were too small (and too well demagnetized) to have any appreciable effect on the work. The other journals of the countershaft system were of bronze or stainless steel, one-half inch in diameter, and ran in bearings of babbitt metal in bronze blocks. All the bearing blocks were mounted either on the bed plate carrying the rotor, on on separate piers of concrete made from white limestone and white Atlas cement.

For horizontal drive, the motors were mounted on separate concrete piers and drove the countershafts directly at 60 r. p. s. The rotor was halfway between the motors, which were nearly nineteen feet apart.

The bakelite tubes are insulators so that no eddy currents were formed in them; also no currents of thermal origin could traverse them. Their lack of great torsional stiffness helped to prevent too great initial acceleration of the rotor, and their flexibility made it unnecessary to take the greatest pains to secure exact alignment. They are also so light that mechanical disturbances when they do not run true are at a minimum.

While the Washington work (I) was in progress, Mr. C. A. Kotterman, now of the Bell Telephone Laboratories, who acted as research assistant, suggested that in order to eliminate friction at the end of the rotor more remote from the motor we use vertical drive instead of horizontal drive. The effect of the torsion produced by this friction was small, however, and was eliminated without great difficulty. At the same time the change to vertical drive would have required a great deal of labor and expense. Hence the change was not made. In the course of the new experiments with horizontal drive, however, it appeared that some of the disturbances might be due to flexure of the rotor by the earth's gravitational field; and in order to avoid this and at the same time reduce torsion it was concluded to adopt Mr. Kotterman's suggestion and modify the apparatus to make vertical drive possible. In the arrangement adopted the rotor was driven from above

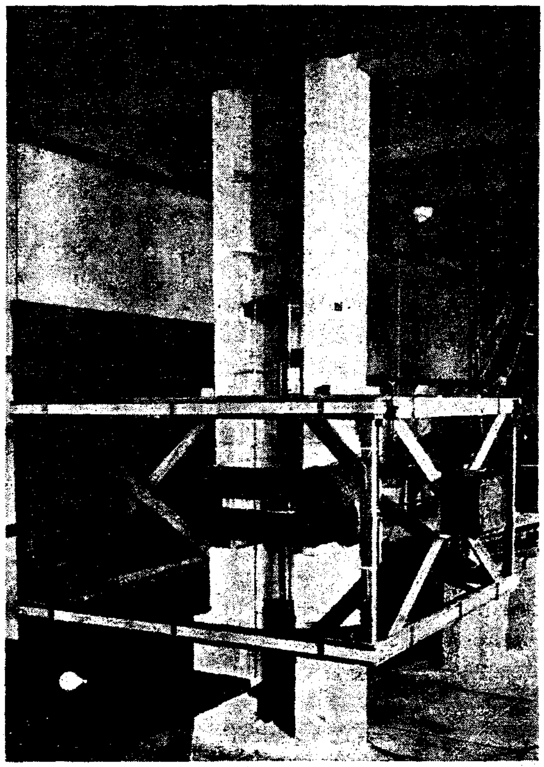

FIGURE 4–2.

only by a single motor, so that the possible torsional effect due to centrifugal thrust of the lower journal against its bearing was not eliminated.

In all the new work the rotors were mounted on the small bed-plate used before, and in bearings which are similar except that bearing bronze is substituted for the agate mostly used before. In a good deal of the work the small cylinders acting as bearing pieces have been slotted, and the clearance between journal and bearing piece adjusted when desirable by means of screws set into the heads of the bed-plate and acting radially at both sides of the slot.

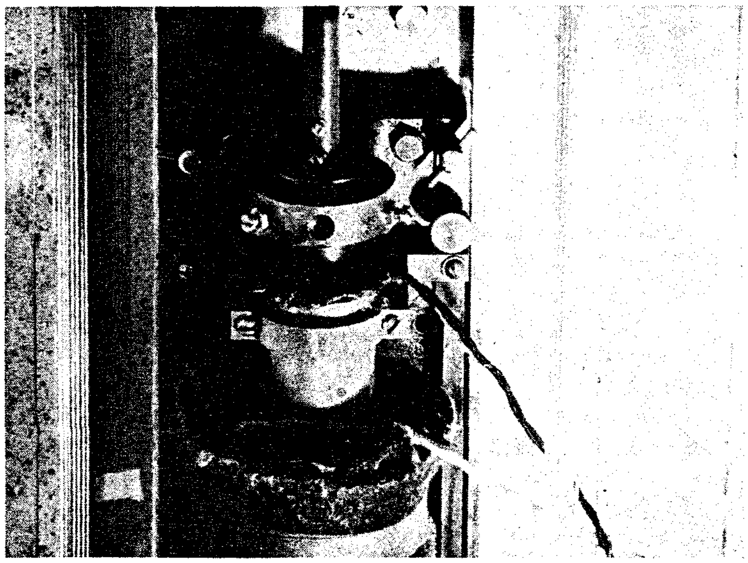

FIGURE 4–3.

In the work with axis horizontal the small rotor bed-plate was mounted on the same heavy bronze bed-plate used for this purpose in Washington; while in the work with axis vertical the rotor bed-plate, the motor and all the extra bearings were mounted on a new long and heavy combination brass-and-bronze bed-plate bolted to a heavy vertical concrete pier resting on the floor, and to a heavy steel beam in the ceiling of the laboratory. See Figs. 4—1 and 4—2.

In Fig. 4—3 the test coil, heavily insulated with felt, is shown mounted in position for vertical drive.

5. THE ROTORS. Most of the rotors are the rotors used in Washington. Three new rotors have been constructed, and one rotor used earlier reconstructed. One of the new rotors is Electrolytic Iron IV. This is from a part of the same rod of iron from which Electrolytic Iron II was formed. Material was lacking to make the magnetic part of this rotor as long as that of the others, and the defect was made up by extending the length of the bronze journal pieces. The diameter is 3.0 cm. and the length of the magnetic material 20.5 cm.

Another new rotor is Electrolytic Iron III. It was cut from a new rod of Dr. Yensen's electrolytic iron, and is 3.0 cm. in diameter.

A third new rotor is Nickel IV, cut from a rod obtained from the International Nickel Co.

Finally, the old rotor Cobalt I, used in Columbus and Washington, was provided with terminals similar to those on the other rotors. The later and better type of construction used in Washington was adopted.

6. MOTORS, SPEEDS, AND CORRECTION FOR IMPERFECT FLUXMETER ACTION. In the earlier work the accurate determination of speeds and the requirement of strictly identical speeds for the two directions of rotation, or of correction for the difference, made a great deal of labor necessary. All this vanished in the new work because alternating current power with the constant and precise frequency 60 cycles per second was always available, and synchronous motors could be used to obtain exactly 60 revolutions per second. Additional speeds were not used.

The motors are 1/8 h. p., self-starting synchronous motors by the General Electric Company. When the unmodified motor is used to drive the equipment, full speed is attained in about 0.5 or 0.6 second after the circuit is closed.

It is highly desirable that this starting interval be as short as possible in order that the galvanometer readings may be interpreted correctly. Nevertheless, when the observations began, it was feared that the acceleration corresponding to the time mentioned would be too great, perhaps for both magnetic and mechanical reasons. Hence an inertia wheel was constructed, in three parts. The first, *A*, is a heavy rolled brass disk provided with an axle and set-screw for attachment to the motor like a pulley. The second, *B*, is a ring of the same material which can be screwed onto one side of the first; and the third, *C*, a similar ring which can be screwed onto the other side of the first. The rings fit accurately over short hubs turned on the two sides of *A*, so that balancing is automatically secured.

The times required to attain full speed with one, two, and three discs, respectively, were approximately 1.1 second, 1.8 seconds, and 2.8 seconds.

While a number of observations were made with one and two discs loading the motors, it was found that all the discs could be discarded; and in most of the work they were not used at all.

It was at first supposed that a correction to the galvanometer readings might be necessary because the fluxmeter action is not perfect and the different effects which act on the secondary circuit, and which the galvanometers integrate, are not completed in the same time. Special time-lag experiments, however, have shown that no correction is necessary except when as many as two discs load the motor. It was estimated that in this case a (negative) correction of about one-fourth per cent should be made to the apparent values of ρ; and this correction has been applied to the relatively few results obtained with two discs.

7. NEUTRALIZATION OF THE EARTH'S MAGNETIC FIELD. If the rotor were strictly cylindrical and homogeneous, and if the surrounding secondary coil were truly cylindrical and regularly wound with its wires truly circular, and were mounted coaxial and otherwise symmetrical about the rotor, then eddy currents due to the rotation of the rotor in the earth's field would produce no resultant flux through the secondary coil, and it would thus be unnecessary (on this account) to annul the field. Partly because these conditions were not completely realized, the chief experiments were made with the earth's mean intensity in the region occupied by the rotor annulled as far as was practicable.

An additional reason for annulling the earth's field is to prevent any change of flux through the rotor due either to a minute change in its altitude or azimuth made possible by the existence of a small amount of bearing clearance, to flexure produced by gravitation or centrifugal action, or to lack of magnetic symmetry.

In the earlier part of the work with axis horizontal, the earth's magnetic field was annulled by two sets of coils of insulated copper wire. The principal set consisted of two pairs of long rectangular coils mounted with their wires (except for the ends of one coil pair) horizontal and symmetrical about the rotor, and thus normal to the magnetic meridian. The coils were all somewhat more than 2.1 m. long, and all were about 25.5 cm. wide (See Figs. 4—1 and 7—1). The mean planes of the coils which annulled the vertical component of the earth's intensity were about 16 cm. apart, and those of the coil which annulled the horizontal component about 17 cm. apart. They were wound in grooves 1/16 inch apart (center to center), cut accurately in square bakelite blocks 25.5 cm. on each side and 2.5 cm. thick. Each coil was kept stretched tight by means of two springs whose tension could be adjusted as shown in Fig. 4—1. The coil pair which annulled the vertical intensity had 26 turns, the other 12 turns. The other set of coils consisted of the large square Helmholtz pair used in the work on the Einstein-de Haas effect, which hung nearby. This coil-pair was connected in parallel with the other vertical-intensity rectangular coil and, as it happened,

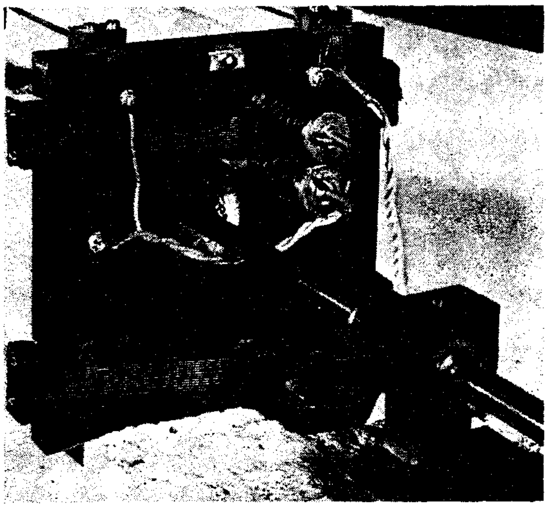

FIGURE 7-1.

made the residual field at the rotor more nearly uniform than it would have been without it.

In the later part of the work with axis horizontal, the large Helmholtz pair was disconnected and the copper wires of the other coils were replaced by No. 20 bare spring brass wires. In each coil the spacing of the grooves prevented the individual wires from touching their neighbors. Vibration of the wires was prevented by the application of small pieces of surgeon's tape.

When the apparatus was mounted with axis vertical, three coils were used to neutralize the earth's magnetic field. See Fig. 4—2. The vertical intensity coil was the coil used for the same purpose in the Einstein-de Haas investigation, which was moved from its old position and mounted symmetrically about the center of the rotor. It was held in position by vertical brass wires attached to the ceiling and horizontal wooden rods connected with the pier. The N-S and E-W components of the horizontal intensity were neutralized by two long coils constructed much like those used in the latter part of the work with axis horizontal. The E-W coil had only two turns in each half; the N-S coil had eight. The bakelite end pieces were securely fastened to the concrete above and below by pieces of brass and bronze; and the wires were held taut by set screws, working in bakelite, which pressed against the upper ends of the loops. By means of the compensating coils the earth's mean intensity in the region occupied by the rotor was reduced to a small fraction of one per cent.

8. TEST, COMPENSATING, AND CALIBRATING COILS. In the work with axis horizontal two pairs of test coils were used, of nearly the same dimensions and with nearly the same numbers of turns. They were mounted as in Fig. 3—1. One pair was wound on bakelite bobbins, the other on brass bobbins. The coils of the first pair were machine wound by the Inca Co., but the windings were not very regular. The coils of the second pair were wound with great regularity by the Hollywood Transformer Co., and were used in the greater part of the work. These coils were six inches long, ½ inch thick, and had internal diameters of 1⅞ inches. Each contained a little more than 14,000 turns of No. 28 enameled copper wire. One coil served as rotor or test coil, and the other as compensator coil.

Three almost exactly similar calibrating coils were wound, one on a bakelite tube, the others on brass tubes. In the case of the last two coils great care was taken to see that the insulation was always perfect (except at one end, where the wire was usually attached to the tube). The first coil was used chiefly in the earlier part of the work. For details of the windings see § 17.

The test coil was mounted with precision, in brass clamps, coaxial with the rotor on the small bed-plate, and the calibrating coil was mounted coaxial inside the bobbin of the test coil. The centers of both coils and the rotor were practically coincident.

In the work with axis vertical, after a few observations made with one of the Hollywood coils as compensator, mounted on the laboratory wall, it was replaced by a large Helmholtz pair centered on the rotor. See Figs. 4—2 and 8—1. Each coil of the pair was nearly square, about 2 ft. on the side, 4 in. wide, and 1 in. thick. The complete coil was wound with 2000 turns of No. 20 insulated copper wire in sections—each divided equally between the two halves, except for a few turns, permitting any even number of turns to be used from 2 to 2000. A special switchboard was provided for making the connections. The coil and board were electrically screened and thermally insulated with felt.

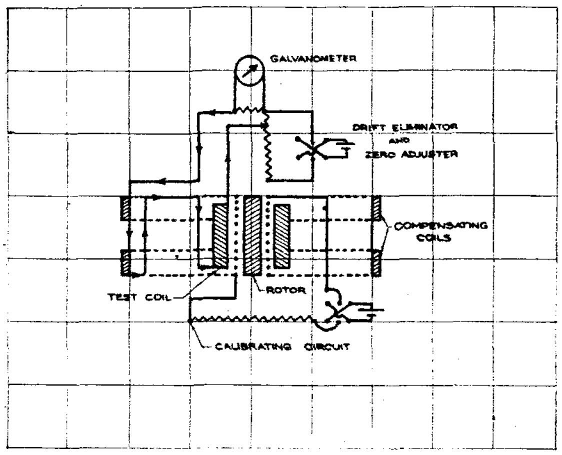

FIGURE 8–1.

In addition to the great advantage of having the compensating coil centered on the rotor and its coil, there are the additional advantages of low resistance and of being able to determine with ease the proper number of turns for exact compensation for each rotor.

An approximate determination can be made by adjusting the current in the vertical earth intensity coil until the vertical intensity is annulled, then adjusting the number of turns until, with the secondary circuit closed through a galvanometer, no deflection occurs when a slight change is made in the current of the vertical intensity coil.

If the field of the vertical intensity coil were uniform throughout the extent of the compensating coil, this determination would be exact. The correction which must be applied to make it exact was readily found by subsidiary experiments made with the help of additional coils of the proper shapes but smaller dimensions. It was found that the number of turns determined as above must be multiplied by 1.007.

It was found necessary to screen electrically the whole secondary circuit. Much of it was insulated thermally.

9. THE GALVANOMETERS, PHOTOELECTRIC CELLS, ETC. In order to attain adequate sensitivity, two galvanometers were used in conjunction with either two similar photoelectric cells or a Moll thermo-relay, which was used in a relatively small part of the work.* The first galvanometer had the characteristics of a fluxmeter. The optical arrangements finally adopted were as follows (See Fig. 9—1):

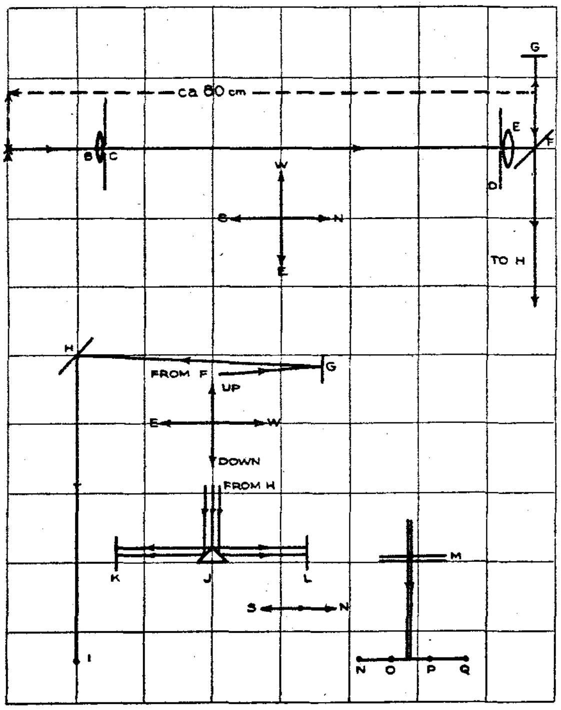

FIGURE 9–1.

A beam of light from the filament *A* of an electric lamp passed in a horizontal plane from *S* to *N* through a short-focus convex lens *B* and a rectangular opening *C* in a thin brass plate in contact therewith, and onward through a circular opening *D* and a long-focus convex lens *E* to a plane mirror *F*. This mirror sent the beam westward and slightly upward until it fell on the plane mirror *G* of the galvanometer in circuit with the rotor and compensator coils. An image of a part of the filament was formed on the mirror *G*. From this mirror the beam was reflected eastward and slightly upward. It fell on a plane mirror *H*, which reflected it vertically downward. An image of the rectangular opening *C* was formed in a fixed position *I* if there was no current through the galvanometer and if no further provisions were made.

When the photoelectric cells were used (Fig. 9—1) the beam was divided into two equal parts by reflection from a right angled prism *J*. An image of half of the opening *C* was formed on the face of each of the cells, *K* and *L*. When the galvanometer mirror moved, the upper edge of each half image remained essentially fixed while the two lower edges moved in opposite directions equally. When the Moll relay was used the vertical beam passed through a cylindrical lens *M*, which concentrated the light from *C*, made narrow for this purpose, on or near the center of the thermocouple *NOPQ*.

With a galvanometer having the characteristics of a fluxmeter there is of course, in general, a more or less slow drift, which it is often necessary to compensate. This was accomplished, when necessary, as in the work of 1914 and 1915, by introducing a minute extraneous electromotive force into the circuit. A single dry cell was connected through a reversing switch to the terminals of the high resistance of an Ayrton shunt. Leads were connected from the variable resistance terminals through an adjustable resistance box to two points, with a very low resistance between them, in the galvanometer circuit. This arrangement not only serves to eliminate the drift but provides a useful device to control the galvanometer while making adjustments.

The mirrors *F* and *H* and the lenses *E* and *M* were provided with all necessary adjustments; and the prism *J*, or the Moll relay *NQ*, was mounted on a small table which could be moved northward or southward by means of a fine micrometer screw.

When the photoelectric cells were used, they were connected in opposition to one another, and either in series or in parallel, in closed circuit with the second galvanometer, suitably shunted to produce critical or approximately critical damping. When the Moll relay was used its terminals *NQ* were connected to the galvanometer terminals through a series resistance sufficient to produce critical damping.

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* I am indebted to Dr. Yensen and Dr. Goetz for information with regard to the photoelectric cells, and to the latter for the loan of the Moll relay.

The galvanometers with their support and all the optical devices, except *A*, *B*, and *C* were mounted inside a box of wood internally blackened and sufficiently tight to prevent trouble from convection currents. Internal blackened screens were also provided to prevent extraneous light from reaching the photoelectric cells and to limit the beam where necessary. The lens *B* and the brass plate with opening *C* were mounted at the end of a large bakelite tube supported on a concrete block and projecting through a wall of the box without contact. The opening between the two was screened with black cloth. The lamp *A* was mounted on a separate concrete pier.

10. THE GALVANOMETER SUPPORT. Since the angular motion of the beam of light after reflection from the mirror of galvanometer *G* is very minute, it was imperative that the galvanometer be mounted on a support as free from vibration as possible. Four thin brass rods were mounted vertical, or nearly vertical, in four brass castings resting firmly on a heavy concrete shelf. A horizontal rectangular wooden board was fastened to the tops of these rods near its corners. From points of this board, also near the corners, but nearer to the center than the rods, four vertical brass tubes proceeded downward. At the bottom, a little above the stone shelf, they carried a second board similar to the first; and at a level about three quarters of the distance from the top to the bottom they carried a third and heavier board. Across the central part of the top of this was screwed a still heavier board on which both galvanometers were mounted. A number of pieces of angle iron were screwed to the boards to prevent their warping. The lower board carried heavy weights, and on top of the upper board were pans of oil to provide internal damping. The masses were all arranged as symmetrically as practicable about a vertical line through the center. The arrangement formed a heavily damped inverted pendulum, and behaved much like the apparatus devised for the same purpose by R. Müller. In Müller's apparatus, however, there were only three rods, instead of four, so that horizontal motions are much more likely to produce angular motion of the suspended system.

11. ELIMINATION OF EDDY CURRENT EFFECTS. Tests for eddy current effects were made in several different ways, as follows:

I. As in the Washington investigation, numerous measurements were made with a copper rotor[5] of nearly the same dimensions as the larger magnetic rotors, similarly placed and rotating both in the earth's unaltered field and in the compensated fields with the same speed of 60 r. p. s. The first experiments were made with the Inca coils in use. In the uncompensated field reversal of rotation gave a mean deflection of + 4.44 cm. when the coil was so set that a mark on its bobbin was as far south as possible. When the coil was set with the mark north, the corresponding deflection was − 1.09 cm. When the field was compensated the corresponding deflections were + 0.86 cm. and + 0.10 cm. The sensitivity was such that the same reversal of rotation of the permalloy rotor would have given the deflection − 15 cm. Thus with the mean field annulled and the coil set at the position angle giving the less effect, the apparent eddy current effect in copper was about 1 part in 150 of the gyromagnetic effect in permalloy and in the opposite direction, indicating that the *apparent* gyromagnetic ratio should be slightly increased. As shown in earlier papers, however, the eddy current effect in the magnetic rotors should be much less than that in copper, and thus much less than 1 part in 150 in the case of the permalloy rotor, with the coil set as above.

In the case of the Hollywood Transformer Company's coils with axis horizontal, the mean eddy current deflection for copper in the compensated field was less than + 0.1 mm. when the sensitivity was such that the gyromagnetic effect in Cobalt II was about + 6.3 cm. The deflection was practically independent of the position angle of the coil (over a range of 270°). When the apparatus was mounted with axis vertical, the copper deflection was − 0.003 cm. when the gyromagnetic deflection for the rotor Fe IV was about − 4.5 cm.

II. Direct experiments on the eddy current effects in the full uncompensated field of the earth were made on two of the magnetic rotors, viz., Permalloy and Norway Iron. The Permalloy was rotated both in the neutral field, in the original uncompensated field, and in the original field approximately reversed. The Norway iron was rotated in the original field and in the original field reversed. The experiments showed that the *full original* field *reduced* the apparent gyromagnetic ratios by the fraction 0.025 ± 0.005.

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[5] The copper rotor had journals which were not insulated from the main body of the rotor. Hence it is possible that a part of the copper effect may originate from thermal *e. m. f. s* at the (bronze) bearings.

III. In a few of the gyromagnetic experiments made with the Inca coils, the rotor coil was mounted with the mark in one of its two positions only. In most of the work with these coils, however, observations in nearly equal numbers were taken with the coil set at this position angle and the angle differing from this by 180°. In one case the eddy current effect, if any, should be many times greater than in the other. For the seven rotors investigated in this group (Group I) the difference between the apparent values of ρ for the two cases was only the fraction 0.003 ± 0.012 of ρ, the average error being thus four times as great as the apparent difference between the two eddy current effects. No correction, was made to the results obtained in either way.

IV. In most of the horizontal drive experiments made with the Hollywood coils, still another test was applied. Half the rotations were made with a mark on one end of the bobbin east, and half with the coil reversed in azimuth and the mark west. The mean difference found for $\rho_E - \rho_W$ was -0.002 ± 0.015.

12. THE POSITION ANGLE ERROR AND ITS ELIMINATION. If the coil, the rotor, and its magnetization possessed perfect axial symmetry, and the various effects above considered vanished, no change of flux through the secondary circuit would occur when the rotor is turned from one position angle to another. On account of asymmetry, however, such changes usually occur. If the rotor is set at a given position angle and then driven up to full speed (or any but a very small speed) the galvanometer gives a deflection P corresponding to the change of flux from its initial value to its mean value; and this effect is added to all the other effects involved. Since it is independent of the direction of rotation it is eliminated from the final result if the rotor is set initially at the same position angle for both directions of rotation. The deflection P retains very nearly the same magnitude, but changes its sign, when the initial position angle is altered by 180°. To make the elimination more certainly complete, each group of observations mark U (or W) and mark D (or E) in the standard sets was made in two parts, (1) and (2), the initial position angles in the two differing by 180°. Also, the initial position angles were in general, but not always, so chosen that the deflection P was a small part of the gyromagnetic deflection R. In some cases P/R was greater than unity.

The effect under discussion was usually investigated for the various rotors by observations independent of the main rotation experiments. In the method frequently employed the rotor was repeatedly set initially at a given position angle, and then turned suddenly in separate experiments from this initial angle to each of a series of angles differing from this by intervals up to nearly 360°. A rough curve was platted between the deflection and the increment of the position angle.

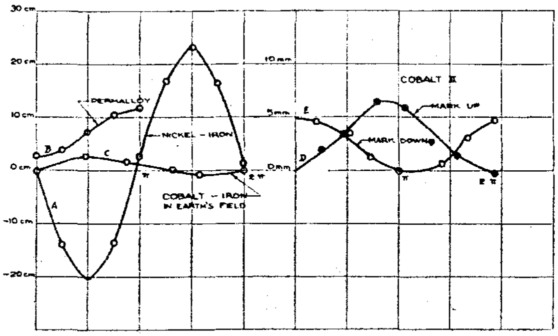

FIGURE 12–1. FIGURE 12–2.

In the main experiments the rotor was then set at the position angles corresponding to the mean deflection. This makes P zero or a minimum.

Curves of this sort are given for several rotors in Fig. 12—1 and Fig. 12—2. All the curves are for axis horizontal except that for Cobalt-Iron, which was mounted with axis vertical. The curve shown for this rotor was obtained when only the vertical component of the earth's magnetic intensity was annulled. This rotor, and some of the others, gave effects too small to measure readily when mounted with axes vertical in a completely neutral field.

13. EFFECTS OF MOTORS AND BEARINGS. Inasmuch as the motors and ball bearings are made of iron they doubtless alter slightly the magnetic intensity of the field acting on the rotor and its coil. There was no reason, however, to expect the rotation of motor and bearing parts to produce any mean effect; and especially there was no reason to expect the *reversal* of their rotations to produce any effect.

Furthermore, direct experiments made with the rotor and compensator at rest and in their standard positions, but with the motor and all the other driving mechanism in rotation except the countershaft nearest the rotor, have shown that these rotating parts produce no certain effect. No effect of the countershafts nearest the rotor was to be feared because they are made of bakelite tubes with only small brass plugs at the ends nearest the rotor. Thus with the Cobalt-Iron rotor in position and at rest, reversal of the motor etc. gave the mean deflection -0.015 ± 0.011 cm. with sensitivity such that a deflection of -8 cm. would have been produced by a corresponding reversal of the rotor's own rotation.

14. Effects of radial forces on rotors. Rough tests were made on several of the rotors set at fixed position angles, to see what would happen in both compensated and uncompensated fields when either end of the rotor was pushed strongly by hand (at a point just outside the bearing) northward and southward, or upward and downward. In one case the middle of the rotor also was pushed. For Cobalt II and Electrolytic Iron IV, which showed very large effects of longitudinal motion, the deflections were only small fractions of the gyromagnetic deflections; likewise for Cobalt I. For Nickel I the deflections were of the same order as the gyromagnetic deflection, but in most cases smaller. For Nickel IV the effects were large, some of them much larger than the gyromagnetic deflection. The effects vary in sign and magnitude with the orientation of the axis of the rotor, with the position angle, with the direction of push, and with the magnetic field, and undoubtedly with other factors, and in such a complicated way as to defy a satisfactory analysis at the present time.

If such effects are produced in the principal experiments on account of asymmetry, by the rotation of the rotor, as they doubtless are, they can have only a small effect on the determination of the gyromagnetic ratios, because they must be nearly identical for both directions of rotation. The only reason they may not be exactly identical is that the rotor journals must move laterally to slightly different positions for the two directions of rotation.

These effects doubtless enter into the quantity designated below as M, which is calculated on the assumption that it is proportional to an even power of the speed, and so independent of the direction of rotation.

If any part of the effect is proportional to the speed, it is probably partly eliminated as the torsion effect is eliminated by reversing the rotor in its bearings and by reversing the drive from one end to the other. The effects usually reversed in this manner and designated below by T cannot be due entirely to torsion, because they are in at least some cases largely independent of the rotor's residual magnetic moment, in both sign and magnitude.

15. Errors due to axial shift of the rotors. When a rotor is driven either right-handed or left-handed, it is possible for several reasons that a longitudinal shift R or L may occur; and the shift may be different for the two directions of rotation. If R-L is not zero a systematic error may thus be introduced.

On this account three series of measurements of longitudinal displacements were made. The first series was made with a telescope and scale while the cylindrical bearings were in use (Group I). With the right motor in operation, no differential effect was observed; with the left motor, a displacement of possibly 1/20 mm. at first occurred. This disappeared, however, when the bearings were oiled, as they were oiled in the gyromagnetic experiments proper. In this case R and L were both zero, and it was estimated that a shift of 1/100 mm. would have been detected.

The second series was made with a microscope after the ball bearings had been installed for horizontal drive (Group II). Probably 0.003 mm. would have been observed, but no shift was detectable. Only one of the two similar sets of bearings was investigated.

The third series was made after the apparatus had been mounted for vertical drive (Group III), with a long range microscope especially constructed for the purpose. Several rotors were used. For Electrolytic Iron III, Permalloy, and Steel IV (a small rotor) the mean measured shifts (R-L) were $+0.002$ mm., $+0.002$ mm. (and again -0.001 mm.), and -0.002 mm., respectively.

Supplementing these measurements, many others were made on the galvanometer deflections produced by moving the rotors longitudinally in their bearings through measured distances of a few millimeters. In each case the mean deflection D produced by moving the rotor eastward (or downward in the case of vertical drive) through a distance of 1/100 mm. was calculated, together with the ratio of D to the gyromagnetic deflection R produced by driving the rotor up to full speed in the right-handed or

TABLE 15—1

EFFECTS OF AXIAL SHIFTS OF ROTORS

1	2	3	4	5
Rotor	Group	$I \times 10^3$	Δ	Δ'
		e. m. u.		
Fe III	I	+0.6	+0.004	+0.004
	III	−0.2	+0.005	−0.002
		+0.2	+0.006	+0.002
Fe IV	II	−0.3	−0.024	−0.024
	III	−0.3	−0.020	−0.023
		+0.3	−0.018	−0.025
		+1.2*	−0.003	−0.003
		−1.2	−0.009	−0.009
		+1.2	−0.009	−0.006
		−0.2*	−0.002	
		+0.2	−0.002	
		+0.2	−0.003‡	
		+0.2	−0.003‡	
Steel III	III	+0.5	−0.004	−0.005
		−0.5	−0.005	−0.008
Ni I	II	−1.4	+0.005	+0.002†
	II	−0.3	+0.005†	
		+0.3	+0.007†	
	III	−0.2	+0.005	
		+0.2	0.000	
Co II	II	+1.6	−0.012	
		+0.3	−0.008	
		−0.3	−0.012	
		+0.3	−0.009	
		+0.6	−0.010	−0.011
		−0.4	−0.016	−0.017
Hopk Al	III	−36	+0.002	+0.003‡
		+36	−0.002	
Permalloy	III	−1.8	+0.003	−0.002
		+1.8	+0.004	0.000
Cobalt Fe	III	+0.3	+0.001	0.000
		−0.3	+0.001	−0.003
Heusler Alloy	III	+0.2	+0.005†	
		−0.2	+0.005†	
Ni IV	II	+2.1	+0.038†	
	III	+0.13±*	+0.002	
		−0.13±	+0.001	
		−0.13±	0.000	+0.005
Co I	II	−1.8	−0.004	−0.004
		+1.8	−0.004	−0.004

* Demagnetized with A. C.

† The record does not show whether the earth's field was compensated or not.

‡ Only the vertical component of the intensity of the earth's field was annulled.

clockwise direction as seen from the west end in the case of horizontal drive (or from above in the case of vertical drive), at the same sensitivity. The mean values of this ratio, designated by Δ for the case in which the earth's field was compensated, and by Δ' for the case of uncompensated field, are given in Table 15—1.

These results, coupled with the observations on the actual longitudinal shifts of the rotors, appear to indicate that in at least most of these typical cases only negligible mean errors could have resulted from longitudinal shift. It was not practicable, however, to keep the bearings in exactly the same state at all times, so that appreciable errors doubtless sometimes occurred.

The magnitude of the quantity Δ is the fractional error in the magnitude of ρ which would result from 1/100 mm. shift.

The quantities $I \times 10^3$ in column 3 are rough values of the mean intensity of magnetization of the rotors multiplied by 1000, the sign in each case indicating the polarity of the downward (or eastward) end.

The effects Δ and Δ' would be expected to vanish if the magnetization were symmetrical about the equatorial plane of the rotor and if the longitudinal gradient of the residual magnetic intensity were zero. The parts of Δ or Δ' due to the gradient should have the same sign for all shifts in Groups I and II, and likewise for all shifts in Group III, as in fact Δ and Δ' often do. The parts due to asymmetry might or might not change sign with the measured magnitude or sign of the magnetization. Both kinds of effect are apparent in the table. A complete analysis seems impossible.

16. PROCESSES INVOLVED IN THE MAIN EXPERIMENTS AND THE STANDARDIZING EXPERIMENTS. In the main experiment, idealized for the case in which no sources of error are present, two processes are involved, equivalent to the following:

(1) In the first process the angular velocity of a rotor is quickly raised from 0 to Ω radians per second, and the galvanometer deflection R due to the change of flux $\delta\varphi_R$ through the secondary circuit is read. The change in the moment of the given rotor in this process is

$$\delta M_R = C\rho\Omega \qquad (16\text{—}1)$$

where C is a constant for the rotor. Then

$$\delta\varphi_R = {}_1K_R\delta M_R + {}_2K_R\delta M_R = K_R\delta M_R = K_RC\rho\Omega \qquad (16\text{—}2)$$

where ${}_1K_R$ and ${}_2K_R$, whose sum is K_R, are constants for the given rotor and rotor coil, and the rotor and compensating coil, respectively. Always ${}_2K_R / {}_1K_R << 1$, and ${}_2K_R$ is nearly identical for all rotors. For the deflection R produced by $\delta\varphi_R$ we have

$$R = A\delta\varphi_R = AK_RC\rho\Omega \qquad (16\text{—}3)$$

where A is constant for the secondary circuit used with the given rotor.

(2) In the second process a small current i_s is sent through the short primary coil surrounding the rotor, and the deflection S due to the change of flux $d\varphi_s$ is observed. In this case we have

$$S = A\delta\varphi_s = A\,({}_1K_s + {}_2K_s)\,\delta M_s = AK_s\delta M_s \qquad (16\text{—}4)$$

where δM_s is the change in the moment of the rotor and coil together, and ${}_1K_s$ and ${}_2K_s$, whose sum is written K_s, are constants evidently nearly equal to ${}_1K_R$ and ${}_2K_R$, but not quite equal because the equivalent intensities of magnetization are not similarly distributed in (1) and (2).

In (1) the intrinsic intensity of rotation, viz. $H_\rho \equiv \rho\Omega$, is strictly uniform, while in (2) the field acting on the rotor is not uniform, nor is the field limited to the volume occupied by the rotor. It is necessary to find the deflection Δ (§ 3) which would be produced by a known *uniform intensity* H_0 acting *on the rotor alone.*

Consider therefore the following procedure. Imagine the solenoid, with diameter and number of turns per unit length unchanged, to be lengthened symmetrically about the rotor to such an extent that its field in the central section occupied by the rotor is essentially uniform, intensity $H_0 = 4\pi ni_s$. Suppose leads to be attached both at the (new) ends and at the points of the winding to which leads were attached before the length was increased.

If now the current i_s were sent through the complete coil, with the rotor in position, we should obtain, instead of (16—4)

$$S' = A\delta\varphi_s' \qquad (16\text{—}5)$$

If the same current were sent through the coil with the rotor removed we should obtain

$$S'' = A\delta\varphi_s'' \qquad (16\text{—}6)$$

Hence,

$$S' - S''\ (\equiv \Delta, \S\,3) = A\,(\delta\varphi_s' - \delta\varphi_s'') = AK_RCH_0 \qquad (16\text{—}7)$$

is the deflection produced when the intensity $H_0 = 4\pi ni_s$ acts on the rotor alone.

From (16—3) and (16—7) we find

$$\frac{\rho\Omega}{H_0} = \frac{R}{S' - S''} = \frac{R}{\Delta} \qquad (16\text{—}8)$$

It is, of course, not practicable to extend the rotor solenoid in situ as imagined above. For this and other reasons we proceed as follows:

We construct another solenoid, exactly like that imagined, and mount the rotor and the coils in the same positions with regard to it. We also replace the two galvanometer arrangement with a single galvanometer less sensitive than either of the other two, and observe the throws D_0' and D_0'' (corresponding to S' and S'') produced by reversing a current I, which is much larger than i_s but still so small that the effects produced remain proportional to currents. In addition we observe the throw D_0 (corresponding to S) produced when the current I is reversed in the central part of the long solenoid (identical in dimensions etc. with the short solenoid) while the rotor is in place.

We now have

$$D_0' - D_0'' = AK_RC \cdot 4\pi nI \qquad (16\text{—}9)$$

in place of (16—7); and

$$D_0 = A\delta\varphi' = AK_s\delta M' \qquad (16\text{—}10)$$

in place of (16—4).

From (16—7) and (16—9) we get

$$\frac{S' - S''}{D_0' - D_0''} = \frac{i_s}{I} \qquad (16\text{—}11)$$

and from (16—4) and (16—10) we get

$$\frac{S}{D_0} = \frac{i_s}{I} \qquad (16\text{—}12)$$

From the last two equations we get

$$S' - S'' \equiv \Delta = (D_0' - D_0'')\frac{S}{D_0} \qquad (16\text{—}13)$$

and thus

$$\frac{\rho\Omega}{H_0} \equiv \frac{R}{\Delta} = \frac{R}{S}\left[\frac{D_0}{D_0' - D_0''}\right] = \frac{R}{S}\,\alpha \qquad (16\text{—}14)$$

where α is written for the quantity within the brackets.

The values of α for the different rotors used in the investigation described here are given in Table 20—1 column 12. They are known to about 0.1 per cent, and are identical for horizontal and vertical drive, and for the Inca and Hollywood coils and the two compensating coils.

From (16—14) we obtain

$$\rho = \frac{H_0}{\Omega}\cdot\frac{R}{S}\cdot\alpha \qquad (16\text{—}15)$$

In the earlier work, both that by the method of electromagnetic induction and that by the magnetometer method, the calibrating deflection corresponding to S was in general obtained for any set either before or after, or both before and after, the rotation experiments proper were completed, and with Ω either very small or zero. In some cases the calibration was made with the rotor at full speed, but little difference was found.

In this work, for a greater degree of certainty, the precaution has been taken, as indicated above, to measure S and R *simultaneously*. Switches are provided by which S and R can be given the same direction or opposite directions at will. In half the work $S + R \equiv A$, is obtained; in the other half, $S - R \equiv B$. Then $R/S = (A - B) / (A + B)$, or

$$R = S\,(A - B) / (A + B) \qquad (16\text{—}16)$$

From (16—15) and (16—16) we get

$$\rho = \frac{H_0}{\Omega}\cdot\frac{(A - B)}{(A + B)}\cdot\alpha \qquad (16\text{—}17)$$

for the final calculation of ρ.

An important reason for this procedure is that in the sensitive arrangement used in this work the sensitivity does not remain steadily constant, but often undergoes changes of a regular, or more or less irregular, character.

Another important reason for this procedure is that it eliminates effects of vibration.

17. THE CALCULATION OF THE GYROMAGNETIC RATIO. Both of the standardizing short solenoids wound on brass tubes (§ 8) had exactly the same diameters (about 41 mm. internal), lengths (about 28.5 cm.), and number n of turns per cm. (44/2.540), the total number of turns in each being 494. They were lathe wound (with screw) from No. 28 cotton-enamel copper wire. The long solenoid was similar, but about 90 cm. long. Thus for each of these solenoids

$$4\pi n = \frac{4\pi \times 44}{2.540}$$

The short solenoid wound on bakelite, through an error on the part of the mechanician who constructed it, had at first 495 turns in its complete length, but was otherwise exactly similar to those wound on brass. The error was discovered, and was corrected, in the earliest part of the work, although the difference was too slight to effect the results appreciably.

The standardizing current L_s was obtained from a single dry cell in series with one or more high resistance coils whose resistance Z was precisely known. Usually Z was the resistance of a standard megohm box. It was never less than one megohm. The electromotive free ψ of the cell was determined almost every night observations were made by comparison with a standard Weston cell, itself repeatedly checked.

The angular velocity Ω in radians per second was always

$$\Omega = 2\pi \times 60$$

For e/m the value 1.759×10^7 was adopted. Thus the formula (16—15) becomes

$$\rho e/m = \frac{4\pi \times 44}{2.540}\,\frac{\psi\,(\text{volts})}{Z\,(\text{ohms})} \times \frac{1.759 \times 10^7}{10 \times 2\pi \times 60} \times \frac{R}{S}\cdot\alpha \qquad (17\text{—}1)$$

When, as usually, $Z = 1$ megohm, this formula becomes

$$\rho\, e/m = 1.0157 \times \psi \times \alpha \times R/S^{6} \qquad (17\text{—}2)$$

---

[6] With $Z = 1$ megohm and ψ approximately equal to 1.5 volt the quantity R/S was always less than unity. See the example in § 18. In the case of a few rotors observations with the Moll relay in use, and horizontal drive, were made both with R/S less than unity, and with R/S greater than unity, R/S in one group being approximately equal to S/R in the other. This was done in order to reduce any error which might originate in lack of proportionality between deflections

The errors in all of the constants are entirely negligible.

18. Example of a set of observations. Determination of ρ, τ, P, and M/R. The procedure in making the observations is described in the next section. An example of one set of observations (with vertical drive) is given in Table 18—2. The symbols RR, RL, etc. used in this table are interpreted in the preceding table, viz. Table 18—1. The first letter refers to the rotor, the second to the calibrating coil. Thus the symbol RR means the deflection produced when the rotor, looked at from above in the case of vertical drive, or from the west end in the case of horizontal drive, is driven clockwise and the solenoid is so connected that it produces a deflection in the same direction as that produced by the gyromagnetic effect in the rotor.

The quantity R is the deflection due to the gyromagnetic effect being investigated, S the calibrating deflection, T the deflection due to the torsion (and other extraneous effects proportional to the speed and reversed with the direction of rotation), M[*] the deflection due to centrifugal and other mechanical effects, and P the deflection due to the fact that when the zero is read just before the motor starts the flux through the secondary circuit has not its mean value for all position angles with the rotor at rest. The subscript U or D indicates that the rotor mark is up or down (W or E for horizontal drive). All deflections are positive when directed to the observer's right.

Each set is divided into two equal parts, one with the rotor mark up, the other with the mark down. Each of these parts is divided into two subgroups, 1 and 2, for which the initial position angles of the rotor are set 180° apart (so that $P_1 = -P_2$).

We thus obtain Table 18—1, where $\overline{RR}$, $\overline{LL}$, etc. are the mean values of the deflections contained in the columns of any subgroup.

In each half set Σ_1 is the sum of all the mean deflections for the subgroup P_1, and Σ_2 the corresponding sum for the subgroup P_2.

M and P have always been calculated for each half set from the formulas given in Table 18—1. The quantities $R \pm T$ and S have always been calculated for the half-groups separately, as indicated in Table 18—2, as an additional check on the work. Also, by substituting $(R + T)_U$ for R_U in the formula for ρ, ρ_u, the apparent value of ρ for mark up has been calculated; and similarly, by substituting $(R - T)_D$ for R_D' in the formula, the *apparent* value ρ_D has been calculated. The true value of ρ is $\frac{1}{2}(\rho_U + \rho_D)$. The quantity $\frac{1}{2}(\rho_U - \rho_D) = \tau$ measures the error in ρ which would have been made on account of torsion etc. except for the end-for-end reversal of

TABLE 18—1

Interpretation of Expressions RR, RL, etc.

P	Mark Up (or W)	Mark Down (or E)
(1)	$RR = R + S + T + M_u + P_U$	$RR = R + S - T + M_D + P_D$
	$LL = -R - S - T + M_u + P_U$	$LL = -R - S + T + M_D + P_D$
	$RL = R - S + T + M_u + P_U$	$RL = R - S - T + M_D + P_D$
	$LR = -R + S - T + M_u + P_U$	$LR = -R + S + T + M_D + P_D$
(2)	$RR = R + S + T + M_u - P_U$	$RR = R + S - T + M_D - P_D$
	$LL = -R - S - T + M_u - P_U$	$LL = -R - S + T + M_D - P_D$
	$RL = R - S + T + M_u - P_U$	$RL = R - S - T + M_D - P_D$
	$LR = -R + S - T + M_u - P_U$	$LR = -R + S + T + M_D - P_D$
	$\overline{RR} - \overline{LL} = \overline{2S} + \overline{2(R + T)}$	$\overline{RR} - \overline{LL} = \overline{2S} + \overline{2(R - T)}$
	$\overline{LR} - \overline{RL} = \overline{2S} - \overline{2(R + T)}$	$\overline{LR} - \overline{RL} = \overline{2S} - \overline{2(R - T)}$
	$\Sigma_1 + \Sigma_2 = 8M_U \quad \Sigma_1 - \Sigma_2 = 8P_U$	$\Sigma_1 + \Sigma_2 = 8M_D \quad \Sigma_1 - \Sigma_2 = 8P_D$

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and fluxes. With one rotor, Heusler Alloy, but by no means certainly for this reason, a systematic difference did appear between the results of the two groups; but there was no certain difference with the others. The mean value of ρ was always taken as correct. The best arrangement would doubtless have been such as always to make $R/S = 1$.

[*] The effects producing M, eliminated by reversal of the direction of rotation, are more complex than was supposed in the earlier work.

TABLE 18—2

EXAMPLE OF ONE SET OF OBSERVATIONS (ON COBALT I). VERTICAL DRIVE.

A. Observations

Deflections in cm.

Mark Up

P	*RL*	*LR*	*LL*	*RR*	*LL*	*RR*	*RL*	*LR*
(1)	−10.96	− 7.53	−18.06	− 0.27	−17.96	− 0.27	−10.93	− 7.60
	10.95	7.66	17.97	0.26	18.04	0.33	10.78	7.56
	10.67	7.60	17.94	0.46	17.97	0.32	10.95	7.58
(2)	−10.02	− 7.30	−17.83	− 0.24	−17.68	− 0.10	−10.58	− 7.37
	10.63	7.23	17.68	0.20	17.76	0.07	10.64	7.53
	10.83	7.13	17.77	0.04	17.82	0.14	10.55	7.35

$(R + T) = 3.60$ $S_1 = 5.24$ $(R + T)_2 = 3.60$ $S_2 = 5.21$

Mark Down

P	*RL*	*LR*	*LL*	*RR*	*LL*	*RR*	*RL*	*LR*
(1)	+ 7.34	+11.02	+ 0.50	+17.66	+ 0.24	+17.74	+ 7.37	+10.97
	7.27	10.93	0.16	17.77	0.29	17.76	7.16	10.76
	7.19	10.76	0.17	17.86	0.17	17.74	7.22	10.85
(2)	+ 7.20	+10.66	0.00	+17.46	+ 0.03	+17.36	+ 7.04	+10.68
	6.87	10.53	+ 0.06	17.36	0.03	17.55	6.77	10.53
	6.90	10.63	0.03	17.47	0.06	17.47	6.85	10.46

$(R - T)_1 = 3.47$ $S_1 = 5.28$ $(R - T)_2 = 3.46$ $S_2 = 5.28$

$\psi = 1.572$ volt $Z = 1$ megohm $[\alpha = 1.007]$

B. Results from Above Set of Observations

$e/m \times \rho_U = e/m \times (\rho + \tau)$	$e/m \times \rho_D = e/m \times (\rho - \tau)$	$e/m \times \tau$	$\rho\, e/m$	R_U	R_D	M_U/R_U	M_D/R_D	M/R	P_U	P_D
1.108	1.055	+0.026	1.082	+3.60 cm	+3.46 cm	−2.52	+2.57	−2.54	−0.13 cm	+0.15 cm

the rotor, or the end-for-end reversal of the drive when the axis of rotation was horizontal.

In Table 18—2, B, as in the corresponding parts of Table 20—1, below, M/R is the mean of the values of M/R and M_D/R_D, the sign of the second being reversed.

19. **PROCEDURE IN MAKING THE PRINCIPAL OBSERVATIONS.** All the observations were made on a regular time schedule. At the beginning of a particular minute on the clock, the rotor having been set at the predetermined position angle (1), and the galvanometer scale having been (slightly) shifted to zero, the switches were closed to produce the deflection *RL* (See § 18). An automatic signalling device caused a neon lamp to glow and a telegraph sounder to click at the end of a fixed interval (usually about 10^s or 8^s, according to the galvanometer circuits in use) after the switches were closed. The galvanometer was read at this instant, and the switches were then immediately opened.

From the beginning of the next successive minutes on the clock the procedure was repeated, except that the switches were set for the deflection *LR*, *LL*, etc., until the eight observations of the first line of Table 18–2 were completed. Then the observations were repeated, in the same order, as indicated in the second and third lines.[7] The galvanometer drift was adjusted, if necessary, at the beginning of each line.

The whole set of 24 observations was then repeated, except that the rotor was set to start from a position angle (2) differing 180° from the previous angle (1). In the case of vertical drive, or in the case of horizontal drive with a single motor in use, the whole procedure was then repeated, but with the rotor reversed in its bearings.

When two motors were in use, drive by west or left motor and drive by east or right motor were interchanged instead of reversing the rotor. The next night, however, the complete process was repeated with the rotor reversed; but if the left (or right) motor was used first the night before, the right (or left) motor was now used first.

In many cases the time interval between successive observations was 2^m instead of 1^m; and in some cases it was $\frac{1}{2}^m$. In many cases the interval between the observation ending one line and that beginning the next was twice the interval between successive observations.

In nearly all cases the electromotive force of the cell furnishing the standardizing current was measured for each set of observations. In many cases the residual magnetic moment of the rotor was measured, often both at the beginning and at the end of the set.

20. THE PRINCIPAL RESULTS OBTAINED IN THIS INVESTIGATION. These are contained in Table 20—1.[8] The first column which requires comment is Col. 3. In connection with this column it should be said that in general all the different groups for a given rotor were not made consecutively, but were distributed (when there was a sufficient number of them) through the work so as to check, if possible, systematic errors which might be different for different conditions.

In Col. 4 the numbers in parentheses are the numbers of sets made in Part I, when the Inca coils were in use. Also, except those at the beginning and end of Part I, the observations were made with the Moll relay in use. These observations in Part I are probably inferior to the others. Also they give, on the whole, somewhat smaller values for ρ. But they have been given equal weight with the others in making the calculations.

Col. 5 gives the mean values of $\rho e/m$ for all the sets, for both horizontal drive and vertical drive, in case both were used. Col. 6 gives the mean for both methods of drive, equal weights being attached to the two. Col. 7 gives the mean value when the observations in each group are weighted proportionally to their numbers. There is little difference between the two.

Col. 8 gives the value of τ calculated on the assumption that the deflection T reverses with the reversal of the rotor's axis, and also with the change of drive from motor east to motor west, or vice versa, when two motors are used. The quantity does not represent an error, but represents the error which would be made except for the reversals introduced to eliminate it.

Col. 9 gives the quantity M/R, the mean of the values of M_L/R_L and M_R/R_R (or M_U/R_U and M_D/R_D), the sign of the second being reversed.

Col. 10 gives the mean value, without regard to sign, of the position angle deflection P to the gyromagnetic deflection R.

Col. 11 gives the quantity $L \equiv$ one-half the excess of $\rho\, e/m$ determined by observations with the left motor alone (for both directions of the rotor mark) over the corresponding value for the right motor. It does not represent an error, but represents the error which would result (in case of horizontal drive) if both motors were not used.

Col. 12 gives the quantity α which, for any rotor, turns out to be identical for the different coil arrangements used in the two methods of drive.

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[7] Instead of three lines of observations, four lines were obtained in a number of sets—half with the galvanometer switch in one direction, half with the switch reversed.

[8] In addition to the results given in this table, two *partial* sets were obtained with the rotor Nickel IV, which was peculiarly susceptible to the effects of mechanical strain, and a number of sets with the rotor Cobalt II, which had worked quite satisfactorily in investigation I, but which showed great discrepancies in the present work. These results have been rejected pending further investigation of the sources of trouble. The mean values of $\rho\, e/m$ for both substances would have been increased by the inclusion of the results mentioned.

TABLE 20—1

PRINCIPAL RESULTS OBTAINED IN THIS INVESTIGATION

1	2	3	4	5	6	7	8	9	10	11	12
Rotor	Drive	No. Groups	No. Sets	$\rho\ e/m$	I Mean $\rho\ e/m$	II Mean $\rho\ e/m$	τ	M/R	$\lvert P/R \rvert$	$L \equiv \frac{1}{2}(\rho_L - \rho_R)\ e/m$	α
Electrolytic Iron III	Horiz.	8	25 (25)	1.020±0.017	[1.020±0.017]	[1.020±0.017]	+0.005 ±0.006	−0.39 ±0.002	1.4	−0.004±0.010	1.012
Electrolytic Iron IV	Horiz. Vert.	2 1	8 4	1.034±0.004 1.024±0.024	1.029±0.005	1.031±0.011	+0.014 ±0.010 −0.014 ±0.018	−0.15 ±0.03 −0.04 ±0.04	0.2 0.04	−0.016±0.014	1.030+
Norway Iron	Horiz.	1	4 (4)	1.028±0.011	[1.028±0.011]	[1.028±0.011]	+0.054 ±0.021	+0.22	0.3		1.015+
Steel III	Horiz. Vert.	1 1	4 (4) 6	1.045±0.009 1.035±0.007	1.040±0.005	1.039±0.008	+0.020[±0.010] +0.002 ±0.007	−0.37[±0.09] −0.36[±0.01]	0.07 0.03		1.006
Nickel I	Horiz. Vert.	6 1	24 (12) 1	1.050±0.030 1.067	1.052±0.008	1.052±0.030	+0.005 ±0.004 −0.011	−2.29 ±0.011 −2.45 ±0.05	0.30 0.25	+0.002±0.005	1.010
Cobalt I	Horiz. Vert.	2 2	8 8	1.070±0.007 1.074±0.004	1.072±0.002	1.072±0.006	0.000 ±0.003 +0.027 ±0.004	−3.64 ±0.00 −2.71 ±0.11	0.12 0.03	−0.015±0.002	1.007+
Hopkinson's Iron—Nickel Alloy	Horiz. Vert.	2 2	8 (8) 11	1.018±0.012 1.019±0.019	1.018±0.000	1.019±0.016	−0.004 ±0.010 0.000 ±0.003	+1.89 ±0.03 +1.60 ±0.26	0.63 0.04	+0.002±0.006	1.049
Permalloy	Horiz. Vert.	2 1	11 (11) 6	1.037±0.001 1.053±0.006	1.045±0.008	1.043±0.003	+0.004 ±0.001 0.000[±0.001]	+0.14 ±0.04 +1.22[±0.001]	0.72 0.01	+0.001±0.002	0.991
Cobalt-Iron	Horiz. Vert.	2 1	16 (16) 6	1.028±0.011 1.030±0.004	1.029±0.001	1.029±0.009	+0.001 ±0.009 0.000[±0.003]	+0.46 ±0.00 +0.60[±0.04]	0.7 0.01	+0.009±0.001	0.994
Cobalt-Nickel	Horiz. Vert.	3 1	14 (6) 5	1.085±0.015 1.054±0.006	1.077±0.015	1.077±0.013	+0.014 ±0.006 +0.002 ±0.007	+0.11 ±0.16 −0.55[±0.00]	0.13 0.02	−0.006±0.004	1.022
Heusler Alloy (Cu, Al, Mn)	Horiz. Vert.	3 2	12 (12) 9	0.976±0.006 1.006±0.006	0.991±0.015	0.989±0.006	+0.001±0.002 −0.004±0.001+	+0.07 ±0.01 +0.05 ±0.01	1.3 0.05	0.000±0.002	1.052
										Mean $L \equiv \frac{1}{2}(\rho_L - \rho_R)\ e/m = -0.003 \pm 0.006$ for above 9 rotors.	

21. COMPARISON OF THE RESULTS OBTAINED IN THIS INVESTIGATION WITH THOSE OBTAINED IN THE OTHER INVESTIGATIONS IN THE AUTHOR'S LABORATORIES. The results obtained in this investigation (III) are compared with those obtained in I and II in Table 21—1. For this purpose all the soft iron rotors are grouped together in each case, likewise the cold-rolled steel rotors, and the cobalt and copper-cobalt rotors.

The most precise values are doubtless those obtained in II. The gyromagnetic ratios for soft iron and permalloy obtained in it are probably current to one-half per cent or less; the others to one per cent, or about one per cent.

TABLE 21—1

GYROMAGNETIC RATIOS OF FERROMAGNETIC SUBSTANCES. VALUES OF $\rho\ e/m$ FROM THE THREE EXTENSIVE INVESTIGATIONS IN THE AUTHOR'S LABORATORIES

(e/m = 1.759 e.m.u.)

Material investigated		Iron	Steel	Nickel	Hiper-nik	Hopk. Al.	Per-malloy	Cobalt	Cobalt-Iron	Cobalt-Nickel	Heusler Alloy
Investigation	Effect										
I	Barnett	1.049	1.047	1.031	—	1.016	1.054	1.070	1.067	1.068	1.011
II	Einstein-de Haas	1.032	1.038	1.051	1.051	1.023	1.046	1.085	1.025	1.076	—
III	Barnett	1.026	1.039	1.052	—	1.019	1.043	1.072	1.029	1.077	0.989
Mean I & III	Barnett	1.038 ±0.010	1.043 ±0.004	1.042 ±0.010	—	1.018 ±0.002	1.048 ±0.006	1.071 ±0.001	1.048 ±0.019	1.072 ±0.004	1.000 ±0.011
Mean of II and Mean I & III	Both	1.035 ±0.003	1.040 ±0.002	1.046 ±0.004		1.017 ±0.001	1.047 ±0.001	1.078 ±0.007	1.036 ±0.012	1.074 ±0.002	

For the materials studied in all three investigations the mean values of $\rho\ e/m$ are as follows: (I) 1.050, (II) 1.047, (III) 1.045. The mean for (I) and (III) agrees exactly with the mean for (II). For the individual materials the means between I and III are given in line 6 of the table. The means between the values in II and those in line 6 are given in line 7. It is probable, however, that the values of III are more nearly correct than the means between I and III.

22. COMPARISON BETWEEN RESULTS OBTAINED IN THE AUTHOR'S LABORATORIES AND THOSE OBTAINED ELSEWHERE. This comparison is made graphically in Fig. 22—1. The chart does not include the author's first observations by a magnetometer method (1917) on cobalt, nickel and iron, which, while useful in that they contained the first results on cobalt and nickel, and showed that the gyromagnetic ratios of these materials are nearly the same as that of iron, contained a (later detected) systematic error which made them certainly too large.

In the chart the abscissae, except for two substances, give the values of the gyromagnetic ratios from the author's investigation II, while the ordinates give the other results. In case of exact agreement with II any point would lie on the oblique straight line. The exceptional substances referred to are Heusler alloy and the oxides of iron, including magnetite. Heusler alloy was not studied (precisely) in II, so that the values obtained in I and III are placed as ordinates against their mean as abscissa. Magnetite and the other oxides of iron, not investigated by the author, are given the same abscissa as soft iron because the recent and extensive work of Ray-Chaudhuri on these substances shows that their gyromagnetic ratios are identical with that of iron within the limits of the experimental errors. The results of Sucksmith and Bates on iron and nickel have been slightly altered on account of the adoption in their work of a slightly incorrect method of calibration.

The close agreement between the results of III and II is apparent, also the generally good agreement between the results of I and II. The mean for iron in I is too high because the exceptionally large value obtained for the gyromagnetic

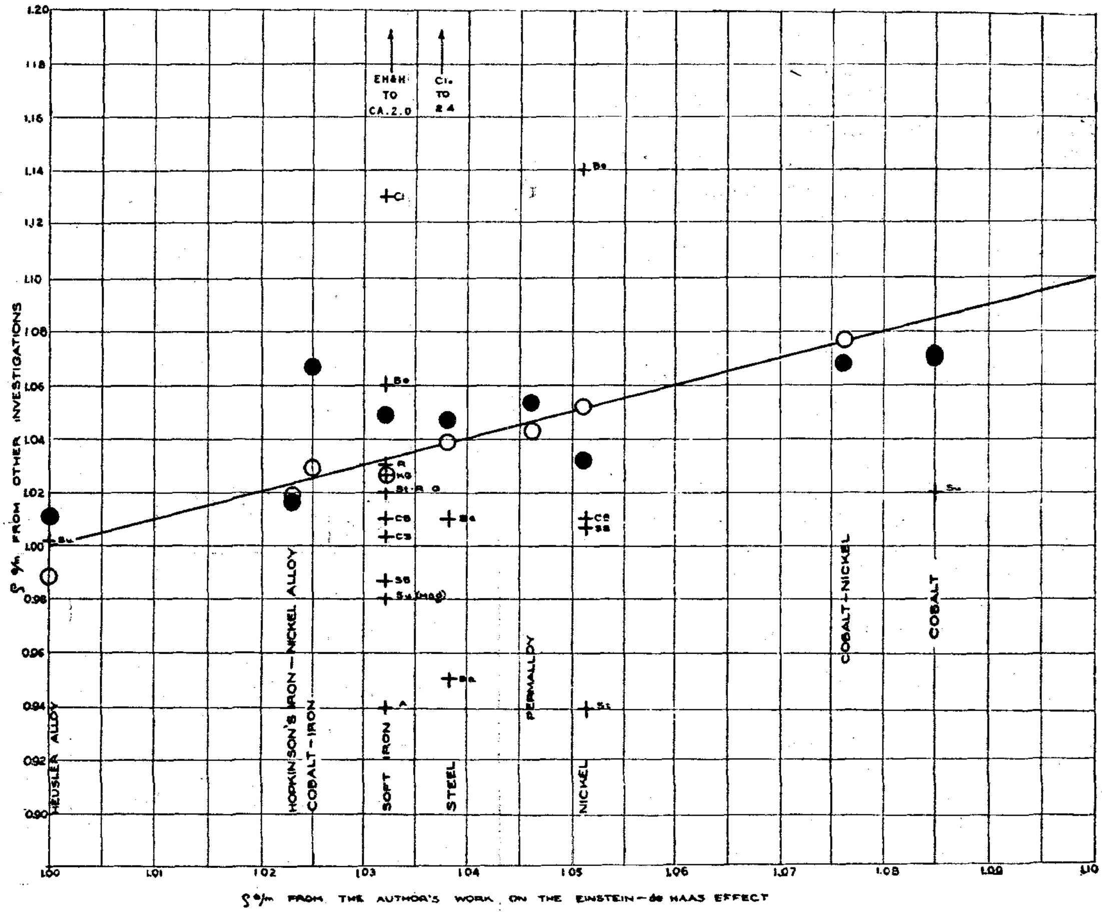

FIGURE 22-1. In this figure the empty circles refer to the present investigation (III); the full circles refer to the investigation I (Barnett & Barnett); the crosses followed by letters refer to other work as follows:

A stands for the work of Arvidsson (1919)
Ba stands for the earliest work of the author (1914 and 1915)
Be stands for the work of E. Beck (1919)
Cl stands for the work of Claassen (1922)
CB stands for the work of Chattock & Bates (1923)
CS stands for the work of Coeterier & Scherrer (1933–1935)
EH stands for the work of Einstein & de Haas (1915–1916)
G stands for the work of Galavics (1939)
H stands for later work of de Haas (1921)
KG stands for the work of Kikoin & Goobar (1938)
R stands for the work of Ray-Chaudhuri (1935)
Su stands for the work of Sucksmith (1925)
SB stands for the work of Sucksmith & Bates (1923)
St stands for the work of J. Q. Stewart (1918)

ratio of electrolytic iron was included. The value for cobalt-iron in I is likewise high. It seems probable that both these chief discrepancies, and some others which occur, are due largely to the not quite complete elimination of errors caused by mechanical strain.

All the most recent values for iron and iron oxides, viz. those of Ray-Chaudhuri, Kikoin and Goobar, and Galavics, are in closer agreement with my value of $\rho\, e/m = 1.032$ for iron than could be expected from their authors' estimated errors alone. For the somewhat older value $\rho\, e/m = 1.00+$ of Coeterier and Scherrer no claim of precision is made.[9] This is likewise true for the larger and, as I believe, more nearly correct value of Galavics.

23. Acknowlegdments. I am again indebted to the Board of Research of the University of California, to the Norman Bridge Laboratory of the California Institute (where the experimental work was done), and to the Carnegie Institution of Washington for the facilities which have made this work possible. For machine work and advice on mechanical matters I have to thank the staffs of the instrument shops of the Institute and the University; and for a great deal of help in the laboratory I am much indebted to Mr. Sheldon Brown, Mr. Donald Webber, and especially Dr. S. J. Broadwell.

The University of California, Los Angeles
Campus
The California Institute of Technology,
Pasadena
October 29, 1943

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[9] In the discussion at Strasbourg, Casimir, who was in Zürich while these experiments were being made, stated that the authors considered the possible error to be about 5 per cent.

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THE FUTURE OF THE ACADEMY

In reviving the custom of an inaugural address, I have no desire to instruct my betters. My state of mind is beautifully set forth in the opening sentences of the earliest communication presented to this society when, in 1780, Governor James Bowdoin, our first president, said: "When I consider, that among the members of the Academy there are gentlemen of abilities superior to my own, especially in the walks of philosophy, I feel a consciousness, that its honours might in one instance have been better placed. But if a defect of abilities could be compensated by a good will to serve its interest, and promote the end of its institution, I should have the satisfaction to think myself not wholly unqualified for the station, with which your suffrages have honoured me." Indeed, if any incoming president were inclined to be pretentious or puffed up, a glance at the names of his predecessors ought to deflate an over-extended ego. Bowdoin, Holyoke, Bowditch, three members of the Adams family, James Jackson, Pickering, Bigelow, Asa Gray—these names adorn the first century of our corporate existence; and if he turns to later and living predecessors, he cannot be comforted. There is a tale concerning John Adams, second president both of this body and of the United States, which is pertinent. When Mr. Adams went to London as American minister, George III, who did not like rebels, said to him acidly: "You succeed Dr. Franklin, do you not?" "No, sir" replied the diplomat, "I do not succeed Dr. Franklin; I merely follow him." I do not succeed Harlow Shapley, I merely follow him.

I have chosen to speak of the present status and possible future of the American Academy of Arts and Sciences. I have consulted nobody, and must bear the sole responsibility for any suggestions I shall make. If these suggestions are dismissed as proceeding from the valor of ignorance, I shall not complain. Many of the problems before an institution like this are perennial, and the only novelty in successive decades is the varying emphasis with which they press upon us for solution. Much that I shall say has probably been better said before. But I shall be content if my remarks awaken in my fellow academicians a sense of our present need for taking stock of the Academy, of ourselves, and of our individual relations to the corporate aim. I have scarcely met with the administrative officers of the Academy, so new am I to this office, but I believe it to be true that neither the President, nor the Council, nor the whole administrative body of the organization taken together, can work out a destiny worthy of our pretensions, unless the lively and continuing interest of a great majority of the fellows is awakened. Disagree with me if you will and denounce me if you must. But if I succeed in arousing debate over the general program of this historic institution I shall have achieved my purpose.

In a period when most educational institutions and many learned societies are taking stock, we, too, can afford to speculate. But if we are to know what we are and whither we are moving, we ought to remember how we came into being and what we have been. The problems of a society like ours are in large measure the result of history. It is therefore wise to glance briefly at the history of academies. That history falls into three grand divisions. In the first of these, academies came into being. In the second, they developed in certain important directions. In the third, they lost ground. These three stages roughly correspond to the seventeenth, eighteenth, and nineteenth centuries.

Following the release of intellectual and cultural forces in the Renaissance, forces which eventuated as humanism or the New Learning, and the new science or Natural Philosophy, it is commonplace that in seventeenth-century Europe, leaders of what was then a radical reinterpretation of man and nature felt the need of mutual support and criticism, and that out of this need such institutions as the French Academy and the Royal Society were born. From their great example we descend. It is again a commonplace that one of the principal issues leading to the creation of these bodies was the necessity of finding or creating a language common to the new dispensation, more accurate than literary language, and better shaped for the purpose than was the technical vocabulary of scholasticism. Much of the theorizing which preceded or accompanied the creation of academies concerned this problem of word and meaning; much of the writing of Bacon, Descartes, and others concerned the problem of communication. They sought an instrument of language which should be at once rational, perspicuous, uncolored by personal emotion, and unperplexed by rhetorical adornment. Their assumption was that all parts of knowledge were equally accessible to any educated person, and that the reporting of experiment and discovery in simple, rational and perspicuous words would render the results intelligible to all who participated in the style. In sum, the kingdom of knowledge was indivisible, its language universal. Membership in the Royal Academy was therefore equally open to poet and scientist, who shared without embarrassment in its discussions.

In the eighteenth century another great addition was made. Specialization in certain fields—for example, chemistry and physics—had increased, and some differentiation of function was necessary. But knowledge was yet sufficiently uncomplicated for a universal genius like Franklin to follow where Bacon, Descartes, Leibnitz and Newton had led, and to contribute to a dozen fields, scientific papers that are models of exactitude in language that is simple and plain. As there seemed to be no reason why this situation should not continue, Franklin founded the first American learned society, with a particular ideal in mind. Not research for its own sake, but research for social ends was the formal purpose of the American Philosophical Society held at Philadelphia for Promoting Useful Knowledge. The test of utility was social applicability. In striking contrast to the Renaissance doctrine that knowledge was a secret to be shared by the uninitiated only, the public diffusion of knowledge had now become a virtue.

This spirit presided over the creation of the American Academy of Arts and Sciences. If we turn to the preface to the first volume of our *Memoirs*, published in 1785, we read: "Societies for promoting useful knowledge may be highly advantageous to the communities in which they are instituted. Men united together, and frequently meeting for the purpose of advancing the sciences, the arts, agriculture, manufactures and commerce, may oftentimes suggest such hints to one another, as may be improved to important ends; and such societies, by being the repositories of the observations and discoveries of the learned and ingenious, may, from time to time, furnish the world with useful publications, which might otherwise be lost . . . Societies instituted for promoting knowledge, may also be of eminent service, by exciting a spirit of emulation, and enkindling those sparks of genius, which otherwise might forever have been concealed; and if, when possessed of funds sufficient for the purpose, they reward the exertions of the industrious and enterprising, with pecuniary premiums or honorary medals, many important experiments and useful discoveries will be made, from which, the public may reap the highest advantages."

This paragraph suggests that, the notion of social usefulness being granted, two important corollaries were drawn by the founding fathers. One was that the learned are under some obligation to hunt out and develop potential talent, and hence it is that academies established competitive prizes such as that, the winning of which first drew public attention to Rousseau. The second was that the proceedings of academies should be a public matter. In the seventeenth century learned men often communicated with each other by letter. Afterwards, the transactions of academies were published. The eighteenth century tended to transform these publications into periodicals which were important vehicles for the diffusion of knowledge to the enlightenment. Such periodicals served the eighteenth century for a variety of functions we have since differentiated, and were, in our terms, reports upon research and discovery, university monographs, extension lectures, correspondence courses, and technical trade journals. Because the fields of learning were still relatively close together, even when a mildly specialized magazine like *The American Journal of Science* was founded, under the shadow of academy practice it took all natural philosophy for its province.

And because universities were not yet what they have become, because industry was still simple, because research foundations were undreamed of, the academy remained a dynamic center for the intellectual world.

If the eighteenth century saw academies at their highest pitch of usefulness, the nineteenth saw their relative decline. The reasons are well known. The most obvious was the increasing differentiation of knowledge, the opening of vast new fields of research, the invention of new specialisms, and the development of unique technological vocabularies. The second was that government took over many of the functions originally developed by academies. The third was the development of the modern research university. The fourth was the creation of the independent research center, industrial laboratory, teaching museum, institute of advanced studies, or other endowed project for the advanced specialist. The fifth was the establishment of gigantic foundations like the Guggenheim Foundation, to search out and support younger research workers or to reward them with prizes and fellowships on a scale beyond the resources of academies.

As a consequence, the academy lost ground. Because specialization of knowledge was accompanied by specialization of vocabulary, one of the first results was to drive the scientist and the humanist apart, so that in the case of our own organization (as an example) humanists tend to stay away from a scientific communication on the ground that they connot understand it. A minor, but unfortunate, result, has been that scholars in the arts have set enthusiastically to work to become as linguistically complicated as the scientists, thus insuring that the scientists could not understand *them*. Eventually, of course, scientists were driven apart from each other.

A second, and more fundamental, change occurred when (the old, undifferentiated academy meeting proving unsatisfactory to the new specialisms), the century developed the greatest number of professional associations the world has ever known. These in turn increased by fissure into still more specialized organizations, so that, to take a simple case, we have not merely the American Historical Association, but within that society or associated with it, groups like the Catholic Historical Society, the Mississippi Valley Historical Society, a group in agricultural history, a group in local history, a group in military history, and so forth. And precisely as the undifferentiated academy meeting proved unsatisfactory, so undifferentiated publications proved also unsatisfactory, and academy publications must now therefore compete with technical and professional journals so infinite in number as to reduce librarians to despair.

The rise of the modern research university has further narrowed our field. It has not merely created, in laboratory and library, centers of personal contact among research workers far more useful than an academy building can hope to be, but it has also given us attractive training centers for young men. Graduate fellowships are a more satisfactory method of encouraging young talent than random academy prizes can become. Moreover, the publication of dissertations, monographs, and books of greater magnitude, at university expense removes from academy lists titles that might otherwise be there, and throws academy publication into competition of the severest sort. Finally, but in the long run most importantly, the universities have developed techniques of begging gifts from the wealthy that leave the simple-minded academician gasping in the rear.

The competition of government bureaus is equally interesting. The early years of the American Philosophical Society and of this academy saw its members writing papers about the weather, tides, weights and measures, geology, mastodons and other topics that, one by one, became the professional province of the Weather Bureau, the Coast and Geodetic Survey, the Bureau of Standards, the Smithsonian Institute and other parts of the national government. These agencies can accomplish cooperatively what, with all their genius, individuals like Franklin and Jefferson could not achieve. Government bureaus are subsidized by public money, the academy is not; and by definition they take over from the academy a role of public service and public education that was one of the original aims of our institution. To be sure, distinguished members of the government services become members of the academies, but this is not the same thing as assuming that the primary aim of an academy is the public service. Finally, of course, government publication competes with academy publication.

Modern industrial research has further complicated our survival problem. Not to speak of the vast equipment ready for the research worker in industrial laboratories, and of the money which can be placed at the disposal of such a laboratory, once it has struck a promising lead, the ambivalent attitude of large corporations towards the results of research they have subsidized must be reckoned with. Some corporations are conspicuous for their sense of civic responsibility; others, it is notorious, buy up brains and hoard discoveries. This latter practice exactly contradicts the generous eighteenth-century belief that the diffusion of rational knowledge is the highest ethical obligation upon the expert; and where the practice of monopolizing research exists, it marks the failure of academies to convert the nation to a right philosophy. More important, however, is the fact that if industry finds it profitable to subsidize its own laboratories, it is not going to donate money to academies except upon terms that are agreeable to industry, and such donations, when they come, are more likely to be for specific projects than for the general public weal.

It would be tedious to rehearse the tale of other agencies which have innocently weakened the influencies of academies. Textbook publishers are a single instance. Nor should it be assumed that academies are obsolescent. In an age of big money, when an ancient institution like the American Philosophical Society is given a large bequest, it wonderfully renews its youth. But if one looks at the general history of academies hopefully founded during the last two centuries, two observations will occur. The first is that many of these, especially those limited to a state or region, have been absorbed by some nearby university as an extramural outlet for research papers, or have become social bodies. The second is a tendency to make election something between an honorary degree and retirement, a recognition of things accomplished rather than a spur to greater things. This danger was recognized by our academy in 1921 when a special committee wisely reported: ". . . it is the duty of the Academy, and its privilege, to encourage work in the Arts and Sciences and to be, through its meetings, a center for getting together once a month a large number of persons interested in learning here in Boston. Reasonably prompt election of young men in this vicinity will aid in the accomplishment of both these purposes. We believe, however, that no one should be elected to the Academy who has not in his own name and by his own determination, already given good evidence, through his publications, of accomplishment, and further evidence of the promise of accomplishment in the future." Because war conditions have taken many younger men away from us, it is perhaps well to recur to the sound advice of the committee and to remember that the reasonably prompt election of young men in this vicinity is one of the most important guarantees that we shall not become senescent.

No one can say, I think, that in 1900 academies were as important in the total intellectual life of a nation as they had been in 1800 or in 1700. All the forces leading to the fractation of knowledge have been more vigorously operative in the last forty years than ever before. Nevertheless, two developments in the twentieth century have indicated an opposite trend. In some sense specialism has defeated itself. That is to say, what once looked like a separate compartment of knowledge, unique and apart from everything else, the more it is explored, the more its boundary lines seem to waver and vanish. The relation of fields is not that of pigeon-holes, but of living, interdependent cells. The historian depends upon the anthropologist, the anthropologist upon the sociologist, the sociologist upon the psychologist, the psychologist upon the biologist, the biologist upon the chemist, the chemist upon the physicist, the physicist upon the mathematician, and so on in an endless circle. It is hard to know whether a given problem lies in chemical physics or physical chemistry. I am supposed to be a literary critic, but I seem to spend most of my time with the historians. In certain advanced areas it is difficult to know whether one is confronting mathematics or theology. The area and language programs of the Army have fused into a common purpose a dozen so-called "disciplines." These random examples show how the very multiplication of specialities has forced the specialists to come together, to exchange ideas, to study each other's techniques, even—what is anathema to the old-fashioned, hard-boiled, realistic investigator—to discuss the philosophy of what they are doing.

And a second pressure towards unity has come from the outside. Students of Western culture have freely said that if we do not recover a common set of ideas, a common tradition, and a common language, we are lost. The wheel has come full circle, but on another plane; and just as men sought in the seventeenth century a means of communicating with each other that would permit the easy flow of generalized ideas, so we, too, perhaps face the same necessity. Certain it is that in any meeting convoked to discuss the state of culture or of education, it is common to lament that knowledge is specialized, to compare its fractation unfavorably with the medieval synthesis or with classical unity, and to demand that we retrace our steps or learn some new mode of common speech.

Much of this appeal, to be sure, is specious. Much of its springs from a nostalgia after a perfect past that never was. Neither classical culture nor the medieval world embraced a fraction of the human beings alive under either dispensation, and the middle ages were not so synthesized nor classical minds so harmonious as this argument seems to imply. Nevertheless, it is an argument of weight, and the question is only: what knowledge is to be intercommunicated, and where can this intercommunication best take place? Let me glance at these problems in reverse order.

Government and industry aside, there are, it seems to me, three sorts of institutions in which specialists might talk to each other, and to some extent do so perform: universities; specially called congresses; and academies. The universities seem at first sight favorable places. None but has its committee on curricular reform. This reform takes the direction of something called "broad" courses, intended to synthesize knowledge for the young, and presumably indicates that their elders feel the need for synthesis. But the confusion of that which is broadening with that which is broad, has never been cleared up by the reformers, and it is amusing to note that this movement mostly creates a new type of educational specialist, the synthesizer. On the whole, moreover, this movement does not affect the mature work of the university, which is that of graduate training and of research. The creation of specialists *is* the professional purpose of universities, and should not be altered. Therefore, laudable though the aim of the reform may be, it seems unlikely that university faculties, to whom research is the principal reward of their intellectual being, will cease to be specialists. But as specialists will they seek to communicate with each other? Yes and no, but I think "No" rather more than "Yes." What stands in the way of organic change is the economic structure of the American university. The basic unit of faculty organization is the department; and however we may pretend that a department is only a committee of the faculty, the truth is, of course, that departments are in grim financial competition with each other, engaging in a kind of *bellum omnium in omnes* for salaries, research funds, promotions, appointments, and endowment. In a universe of experts the unspecialized goes to the wall. The specialist cannot desert the professional flag, and must, *ex hypothesi*, stick pretty well to his department.

The next possibility is the special congress, of the type of the Conference on Science, Philosophy and Religion annually convoked at Columbia University. That these yearly meetings accomplish something in cross-fertilization and cross-simplification is probably true, but in the nature of the case their influence is intermittent and appeals only to the people to whom it appeals. Moreover, these congresses sometimes produce effects the opposite of what they intend. Their search for a common language leads to the creation of elaborate verbal structures that, in seeking accuracy, achieve a new complexity, and this search for absolute definitions throws emphasis upon techniques and procedures rather than upon ideational content. Their second weakness is an inevitable tendency towards evangelicism, which is socially laudable but not the same thing as using a language common to all disciplines. Let us not forget that one of the aftermaths of the International Congress of Religions at the World's Columbian Exposition was an increase in the number of sects.

An academy, however, is free from the internecine warfare of the departments and is a more stable body than the annual congress. There being no problems of promotion or salary increase to disturb our republican simplicity, we ought to be an institution in which specialists can relax; and as we are committed to serve, but not to remake, the body politic, our processes can be ideological rather than passionate. Nevertheless, our usefulness is also severely limited, and unless we are prepared courageously to face these limitations, we may yet join other venerable Boston organizations of historical importance only. If this be treason, make the most of it.

In shaping this academy our predecessors recognized even in simpler times the differentiation of knowledge, by establishing the several classes and divisions of our membership. Yet, except as a device for maintaining balance in electing new fellows and except for fulfilling certain constitutional provisions, the academy seems not to recognize the problem set by its own organization. Our aims are contradictory. On the one hand, our monthly "communications," operating on eighteenth-century postulates, are supposed to be couched in such language that all sensible men can understand them. On the other hand, we exist for the advance of knowledge in the several fields represented by our sub-sections, the heritage of the nineteenth century. If a fellow presents the results of research in his specialty, it is possible that only members of his own class and subsections will fully comprehend him; yet if his research is to receive competent criticism by the academy, he ought not abate one whit of its intricacies, albeit in proportion as he is accurate and detailed, his audience will necessarily diminish. On the other hand, if members address the general meeting, as they do, they cannot hope to present specialized problems without simplification, thereby running the double risk of wearying the competent and of talking down to the uninitiated. Good sense, to be sure, gets many a speaker around this difficulty, and the very challenge of the occasion sometimes compels a useful clarification. Nevertheless, here is a difficulty which severely limits the program committees in its choice of speakers and of topics. It is also a difficulty which leads to eccentric results in the size and character of academy audiences.

But what most troubles me is not these pragmatic considerations, but the begging of the question of the relation of the academy to research. I do not believe we exist for the amiable exchange of lectures. I thing our primary duty is still that of our charter, which is "to promote and encourage . . . knowledge . . . and . . . to cultivate every art and science, which may tend to advance the interest, honor, dignity and happiness of a free, independent, and virtuous people." As I understand this language, it says that the cultivation of our several departments of work is the primary duty of the Academy, which, by bringing mature men and women together in their several fields, seeks to encourage their investigations. So far as we are under any obligation to inform the general public about what is going on in our separate specialties,—and that it is a duty I grant—that duty nevertheless seems to me secondary to our principal purpose—our directive, in modern lingo. But I am frank to say our meetings do not always carry out that principal purpose. I am by no means clear that our present type of monthly meetings is the sole type of program we can usefully support; and if we have to choose, I think we ought rather to imitate the work of the Institute of Advanced Studies at Princeton than the work of the Lowell lectures, excellent for their purpose though these latter may be. In short, I suggest the time has come to re-study the whole question of the nature, number, and function of our monthly "communications."

But if the encouragement of research is the primary business of the academy, what, it will be asked, becomes of the hunt for a common language? If I raise the question whether the present pattern of our meetings efficiently carries out the original aim and primary purpose of this society, I must not be understood as saying that all our gatherings should be devoted to matters so technical that only a few can comprehend them. I am far from implying that our general meetings should disappear. But they should not be our only type of meetings. I do most firmly believe that the spirit of research at advanced levels rather than the spirit of reporting even at high levels is essential to the healthy life of an academy. I do not see how we can hold the real attention of younger members unless we somehow vigorously implement the statement of the 1921 committee that this academy must be a center of learning in Boston. If we attempt to reduce complex problems of investigation to postulates so simple that all the members of the Academy will immediately understand them, I do not believe young specialists are going to keep up an eager interest in our meetings. I therefore suggest that to study the problem of differentiating our meetings, to compare our success with that of the American Philosophical Society, which, as most of you know, follows a different plan, to review the purpose and function of these meetings, and, indeed of the Academy as a whole, seems to me primary business of our immediate future.

But I may seem to depart from the notion that academies exist in order that learned men may talk a common language. As I earlier indicated, this call to retreat up the stream of time to simpler eras seems to me specious. I do not believe such a retreat is practicable. I think the problem is wrongly phrased. I should myself put it this way: that our problem is not whether a common language can be artificially reinstituted among learned men, but whether this Academy is not charged with the duty of creating a common climate of opinion. My observation is that the research spirit does not depend upon vocabulary but upon an exciting philosophy of values. In my wanderings over the republic it has seemed to me that those institutions were stimulating, not where the chemists were concerned lest the literary critics could not understand them, but where the chemists and the literary critics were alike committed to an exciting intellectual existence. I think institutions of learning grow or decline, are active or dormant, in proportion as they dare to foster great projects, dream of great issues, and dare to embark upon great and important programs. Will the American Academy of Arts and Sciences rise to the height of the great argument which brought it into being, or will it be content to become simply another Boston institution?

To be sure, we at present offer prizes and subsidize research projects in proportion to our modest means. That is all to the good. If we do not do better, our excuse is: lack of funds. I do not question the utility of our present practice, but it is utility on a lower level. I shall be bold enough to say bluntly that this academy does not now foster enterprises of that magnitude and daring the founding fathers had in mind when they wrote in 1785: "It is the part of a patriotic philosopher to pursue every hint—to cultivate every enquiry, which may eventually tend to the security and welfare of his fellow citizens, the extension of their commerce, and the improvement of those arts, which adorn and embellish life." In an age committed to cooperative enterprise, we who are, or ought to be, the pattern of cooperative enterprise in New England intellectual life must realize our opportunity. We must think largely and generously, not in terms of *ad hoc* projects and parochially. What enterprises can we foster? What is our potential contribution as a corporate body to the life of Boston, of Massachusetts, of New England, of the nation? Dare I say that in any realistic census of the intellectual forces at work in the dominion of New England this academy would not now possess that commanding and central place it ought to have? But we should not be simply another Boston society, we should be *par excellence* the commanding intellectual institution in all the New England states. In place of searching the rolls of colleges and of industry for new members, we should have colleges and industry searching our membership for talent. In place of requesting Dr. X or Professor Y to tell us what is going on in the Massachusetts Institute of Technology or at Washington or in the Museum of Fine Arts, we should have M. I. T. and Washington and the Museum anxiously and hopefully inquiring: what is forward at the American Academy of Arts and Sciences? We have, or had, or should have, a central position in New England culture; is it conceivable that this academy may again become a dynamic center from which lines of intellectual energy shall radiate to all parts of these states and even to the nation at large? I do not believe it is the excitement of the moment that leads me to say that the future before the American Academy is immense, provided the Academy will bestir itself. But it cannot remain passive. It must renew its life. It must announce programs of imaginative daring. It must not indulge that spirit of historical defeatism which a newspaper man has just told me is characteristic of Boston.

It will be said that money and time are lacking, that existing institutions, already heavily endowed, absorb potential funds and monopolize public attention. This is a weak argument. Money never comes to the timid, just as it never comes to the planless. But if a millionaire came to this building tomorrow to inquire what the Academy had in mind, what could we say to him as a corporate body? No one is going to give to the Academy on the ground that it is vaguely a good thing to support. Only a dynamic program will attract attention to us. And though I would by no means confine the activities of our fellows to any restricted sphere, I am going to crown these audacities by suggesting one form of activity in which the Academy could make itself felt at once.

Boston, Massachusetts, and New England face difficult years, and so far as I can discover, no single body is at work to study the problems immediately ahead. To be specific: we do not know what to do with or for the Port of Boston. We do not know how to relieve the racial and religious tensions among us. We do not know what to do with the apparently moribund agrarian economy of New England. We do not know whether our industries can continue as they have been. We do not know precisely what our natural resources as a region are. If this meeting were held in Chapel Hill, North Carolina, it would be unnecessary for me to say that a survey and a study of the problems of the region at our doors is a primary obligation upon a learned body of disinterested men living in that region. As it is, I suggest that if, after mature consideration of these possibilities, the American Academy of Arts and Sciences were to announce in the public prints that it proposed to embark upon a generous and long-range study of these, and allied, problems, making public the findings of expert members of its body and having no further ax to grind than that of fulfilling the injunction of its founders to bring such information to bear upon our social life as may eventually tend to the security and welfare of our fellow citizens—I say, if the Academy, after mature deliberation, should announce this as one of its present aims (but by no means the only one) I am convinced the tonic effect upon the Fellows and upon the region in which we live would be immense. I venture to prophesy that money and means could be found. I venture to suggest, in fact, that we may even be under some obligation not to stand passive when the economic, the social, and the intellectual life of the commonwealth needs study and support.

Such a project might revolutionize some of our activities, but I do not say that it should revolutionize all of them. I do not argue that our astronomical Fellows should calculate the orbit of the next comet only with reference to Newbury Street. But I feel profoundly that the American Academy of Arts and Sciences is one of the great enterprises descending from the eighteenth century, and I am deeply concerned that it should fulfill the measure of its greatness. I think it should have a place in the life of this commonwealth comparable to that of the Boston Symphony Orchestra, the Massachusetts General Hospital, or the great colleges, institutes and universities round about, which it would be invidious to particularize. I am concerned lest we shall be without vision. I am uneasy lest we break into disparate entities and fail of common purpose. I should like to see us launch greatly upon great enterprises. Unfortunately neither a scientist nor a social scientist, I cannot sketch a specific program of action, but I most earnestly hope these suggestions will be taken up by Fellows competent, as I am not, to translate them into action.

I believe we should create a specially appointed commission of Fellows of the Academy to review and re-examine the whole structure of this ancient institution. Without prejudice to the admirable work of the Council, the Secretaries, and the standing committees, I think this commission should be a special and independent body, having (within the limits of our treasury) funds at its disposal to implement its study, by travel, by calling upon witnesses, and by such other means as seems necessary. I think it should in good time bring in a printed report of such depth and magnitude as will bring immediately home to each of us the problem of the Academy and its future in a world that may seem to have outgrown these primitive institutions. I suggest this body might take as its principal inquiries these:

1. The nature of the organization of the Academy and of its meetings, in relation to the furtherance of research and of intellectual cooperation in New England.

2. The responsibility of the Academy for the intellectual life of New England, and the possibility of making this body and the building in increasing degree a focal point for joint enterprises, cooperative projects, and the like.

3. The question of the Academy building—cannot it be repaired and modernized so that it will better further the purposes of the Academy?

4. A campaign for increasing the endowment of the Academy, having in mind specific programs upon which the Academy may fruitfully embark.

This is, I know, ambitious. It may seem to many of you vague. Perhaps I am raising these questions in the wrong place or in the wrong way or at the wrong time. But I have a feeling that what we determine to do in the next two or three years will powerfully influence our whole future existence; I have a feeling that, rich as is New England in institutions of learning, they will welcome some positive program to link together the interests of the learned and the problems of society in the years immediately to come; and I earnestly desire that the American Academy of Arts and Sciences, the second oldest learned society in the United States, should assume the captaincy and take the lead because, it seems to me, history and tradition say that it should do so.

RECORDS OF MEETINGS

One Thousand Two Hundred and Eightieth Meeting

October 14, 1942—Stated Meeting

The Academy met at its House at 8.25 P. M.

The President in the Chair.

This meeting has been designated as Ladies' Night, and there were present 250 Fellows and guests.

The records of the meeting of May 13 were read and approved.

The following communications were presented:

George Sarton: "Leonardo, Man of Science."

Otto Benesch: "Leonardo da Vinci and the Beginning of Scientific Drawing."

Dr. Benesch also arranged an exhibit of reproductions of some of Leonardo's scientific drawings, consisting of facsimiles loaned by the Fogg Art Museum and of illustrated books loaned by the Harvard University Library.

The meeting was dissolved at ten o'clock.

One Thousand Two Hundred and Eighty-first Meeting

November 18, 1942.—Stated Meeting

The Academy met at its House at 8.27 P. M.

The President in the Chair.

There were present thirty-three Fellows and eighteen guests.

In the absence of the Recording Secretary, the Corresponding Secretary acted as Recording Secretary *pro tem.*

The records of the meeting of October 14 were read and approved.

The Corresponding Secretary reported the receipt of letters accepting Fellowship from Francis Birch, John Nash Douglas Bush, William Irving Clark, Samuel Cornette Collins, Donald Kirk David, Howard Sylvester Ellis, Russell Gibson, Roger Sherman Greene, Otto Kinkeldey, Wassily W. Leontief, Samuel Albert Levine, Richard Peter McKeon, Daniel L. Marsh, William Ralph Maxon, Hermann Joseph Muller, William Andrew Paton, Paul Anthony Samuelson, and Otto Struve; also a letter accepting Foreign Honorary Membership from Lorenzo Raimundo Parodi.

He also reported the receipt of letters resigning Fellowship from Edward H. Chamberlin, Henry T. Lummus and Edgar H. Sturtevant.

A vote was then taken on a proposed amendment to the Statutes, Chapter II, Article 2, which had been recommended to the Academy by the Council at the annual meeting last May, as follows:

"Fellows of the Academy on retiring from their academic or other regular duties may, if they so desire and with the approval of the Council, be transferred to the status of Fellows Emeriti. Fellows Emeriti shall be exempt from the payment of dues and may not hold office in the Academy, but shall have all the other privileges of Fellowship. In the published lists of the membership of the Academy, Fellows Emeriti shall be separately classified and shall be outside the statutory limit set on the number of Fellows."

This amendment was adopted by a vote of twenty-eight in favor and one against.

The following communication was presented:

Charles W. Eliot, 2nd: "City Planning."

The meeting was dissolved at 9.46 P. M.

One Thousand Two Hundred and Eighty-second Meeting

December 9, 1942—Stated Meeting

The Academy met at its House at 8.30 P. M.

The President in the Chair.

There were present forty-one Fellows and twenty-one guests.

The records of the meeting of November 18 were read and approved.

The Corresponding Secretary reported the receipt of a letter from Gordon W. Allport, resigning Fellowship.

The following communication was presented:

Ross A. McFarland: "Human Problems in Aviation," illustrated with slides and moving pictures.

An exhibit in the Reading Room showed recent astronomical discoveries: a first magnitude nova, a new comet, evidence for a planet in another stellar system.

One paper was read by title: "The Advent of the Microscope in America, with Notes on its Earlier History," by Frederic T. Lewis.

The meeting was dissolved at 10.10 P. M.

One Thousand Two Hundred and Eighty-third Meeting

JANUARY 13, 1943—STATED MEETING

The Academy met at its House at 8.25 P. M.

The President in the Chair.

There were present thirty-nine Fellows and sixty-one guests, many of them headmasters of public and private schools, who had been specially invited to this meeting.

The records of the meeting of December 9 were read and approved.

The Corresponding Secretary reported the receipt of a letter from Henry J. Cadbury accepting his election to Fellowship.

He also announced that the Council had appointed Melvin T. Copeland and Edmund M. Morgan to fill the vacancies in the Council created by the resignations of Edward H. Chamberlin and Edward S. Thurston, for the rest of the academic year.

The following communication was presented:

Henry M. Wriston: "The Problem of the Liberal Arts College."

In the Reading Room there was exhibited a selection of notable specimens of mathematical texts, printed in each century from 1500 to the present.

The meeting was dissolved at ten o'clock.

One thousand Two Hundred and Eighty-fourth Meeting

FEBRUARY 10, 1943—STATED MEETING

The Academy met at its House at 8.29 P. M.

The President in the Chair.

There were present thirty Fellows and fourteen guests.

In the absence of the Recording Secretary, the Corresponding Secretary acted as Recording Secretary *pro tem.*

The records of the meeting of January 13 were read and approved.

It was announced that a special meeting was to be held on April 6 in honor of Governor Bautista and Ambassador Najera of Mexico.

The following communication was presented:

Paul C. Mangelsdorf: "Economic Plants as Weapons of War."

An exhibit of photographs, drawings and materials collected on the site of the Boylston Street Fishweir, was described by Dr. Frederick Johnson.

The meeting was dissolved at 10.02 P. M.

One Thousand Two Hundred and Eighty-fifth Meeting

MARCH 10, 1943—STATED MEETING

The Academy met at its House at 8.34 P. M.

The President in the Chair.

There were present forty-eight Fellows and twenty-six guests.

In the absence of the Recording Secretary, the Corresponding Secretary was asked to assume his duties.

The records of the meeting of February 10 were read and approved.

It was announced that the President had appointed the Nominating Committee, as follows:

Ernest H. Huntress, of Class I
Ivan M. Johnston, of Class II, *Chairman*
Dumas Malone, of Class III
S. Foster Damon, of Class IV

On the recommendation of the Council the following appropriations were voted for the year 1943–44:

From the income of the General Fund, $6,825, to be used as follows:

for House expenses	$2,200
for General and Meeting expenses	900
for Library expenses (salaries, books, periodicals and binding)	2,625
for Treasurer's expenses	1,100
	$6,825

From the income of the Publication Funds, $2,000, to be used for publications.

From the income of the Rumford Fund, $3,000, to be used at the discretion of the Committee.

From the income of the C. M. Warren Fund, $750, to be used at the discretion of the Committee.

The President announced that there would be a special meeting on April 6, in honor of Governor Gonzalo Bautista, of the State of Puebla, Mexico, and Ambassador Najera, and that this would take the place of the regular April meeting.

The following communication was presented:

Manley O. Hudson: "International Organization after the War."

The meeting was dissolved at 10.04 P. M.

One Thousand Two Hundred and Eighty-sixth Meeting

APRIL 6, 1943—SPECIAL MEETING

A special meeting was held at the House of the Academy at 8.30 P. M. at which the guests of honor were Dr. Gonzalo Bautista, Governor of the State of Puebla, Mexico, and His Excellency, the Mexican Ambassador. Nearly three hundred persons were present, including members of the Pan-American Society of Massachusetts, and members of the families of Fellows.

The program was as follows:

Presentation of the greetings of the Academy to its guests: President Shapley.

Response by Governor Bautista.

Address: "Mexican-American Cultural Relations:" Ambassador Najera.

Address: "Earthquakes, Volcanoes and Mountain Systems of Mexico:" Professor Kirtley F. Mather.

Reception in honor of the Governor and the Ambassador.

There was a special exhibit of reproductions of pre-Columbian Mexican manuscripts, and another of seismograms.

This meeting took the place of the stated April meeting of the Academy, which would have been held on April 14.

One Thousand Two Hundred and Eighty-seventh Meeting

MAY 12, 1943—ANNUAL MEETING

The Academy met at its House at 8.22 P. M.

Vice-President Robinson in the Chair.

There were present forty-four Fellows and twenty guests.

The records of the meetings of March 10 and April 6 were read by the Corresponding Secretary in the absence of the Recording Secretary and approved by the Academy.

The Corresponding Secretary made the following announcements from the Council:

The Permanent Science Fund Committee has been reappointed: John W. Bunker, *Chairman*, George R. Agassiz, Kenneth T. Bainbridge, Gregory P. Baxter, Charles T. Brues, Hudson Hoagland, Walter S. Hunter, S. Burt Wolbach.

The following grants have been made from the Permanent Science Fund:

1. To Elso S. Barghoorn, Jr., Instructor in Biology, Amherst College, for expendable materials, compensation for assistance, and field expenses in a continuation of his studies on the structural and mechanical changes which occur in submerged wood and other plant remains, $350.

2. To Alfred Rehder, Curator of the Herbarium, Emeritus, Arnold Arboretum, for one-half the cost of library work in various cities for completion of the manuscript on the Bibliography of Cultivated Trees and Shrubs, $100.

Professors Edward K. Rand and Carl N. Jackson have been transferred to the status of Fellows Emeriti, in accordance with the amendment to the Statutes adopted by the Academy in November 1942.

A letter has been received from Wilmer Lanier Barrow accepting his election as a Fellow.

At a special meeting of the Council on April 20, the following were elected to Fellowship in the Academy:

CLASS I

Section 1. Edwin Powell Hubble, Pasadena, Cal.
Cecilia Helena Payne-Gaposchkin, Lexington
Section 2. Enrico Fermi, Leonia, N. J.
Philipp Frank, Cambridge
Edwin Herbert Land, Cambridge
Donald Charles Stockbarger, Belmont
Section 3. Hugh Stott Taylor, Princeton, N. J.
Section 4. Bradley Dewey, Cambridge

CLASS II

Section 1. Lewis Don Leet, Harvard
Section 3. David Bruce Dill, Arlington
Brenton Reid Lutz, Melrose
Section 4. Arlie Vernon Bock, Cambridge
Chester Scott Keefer, Brookline

CLASS III

Section 1. Charles Edward Wyzanski, Jr., Brookline
Section 2. Payson Sibley Wild, Jr., Cambridge
Section 3. Augusta Fox Bronner (Mrs. William Healy), Boston

Benjamin Morris Selekman, Cambridge

Section 4. Ada Louise Comstock (Mrs. Wallace Notestein), Cambridge

CLASS IV

Section 1. Angus Dun, Cambridge

Section 2. Carleton Stevens Coon, Wakefield
Hugh O'Neill Hencken, Chestnut Hill

Section 3. Perry Gilbert Eddy Miller, Cambridge
Jean-Joseph Seznec, Cambridge

Section 4. Leonard Bacon, Peace Dale, R. I.
Willa Cather, New York, N. Y.
Randall Thompson, Charlottesville, Va.
Thornton Niven Wilder, New Haven, Conn.

The following reports were presented:

REPORT OF THE COUNCIL

Since the last report of the Council the deaths of twenty-one Fellows have been reported: Joseph Henry Beale, Stephen Vincent Benét, Franz Boas, Ralph Adams Cram, John Frank Daniel, Davis Rich Dewey, Frank Edgar Farley, James Edmund Ives, James Richard Jewett, John Ellerton Lodge, Abbott Lawrence Lowell, Charles Thomas Main, Edward Caldwell Moore, George Andrew Reisner, Robert Wilcox Sayles, Charles Schuchert, Andrew Watson Sellards, William Albert Setchell, Joseph Warren, Grenville Lindall Winthrop, Joseph Ruggles Worcester; and of four Foreign Honorary Members: Frank Dawson Adams, Sir Joseph Larmor, Charles Tate Regan, Richard Willstätter.

Twenty-one Fellows and one Foreign Honorary Member were elected by the Council and announced to the Academy in May 1942.

The roll now includes 773 Fellows, 2 Fellows Emeriti, and 119 Foreign Honorary Members (not including those elected in 1943).

REPORT OF THE TREASURER

*RECEIPTS

Academy, General:			
From: Investment Income (Schedule D)	$12,507.28		
Less: Income to Special Funds	9,548.95		
		$2,958.33	
Assessments and Admission Fees		4,175.00	
			$7,133.33
Amory Fund Committee:			
From: Investment Income			$2,913.87
Publications Committee:			
From: Investment Income		$2,384.53	
Sale of Publications		682.50	
Rumford Fund		720.00	
Subscriptions, Lake Publication		255.80	
			4,042.83
Rumford Fund Committee:			
From: Investment Income			3,061.00
Warren Fund Committee:			
From: Investment Income			967.73
Mabel S. Agassiz Fund:			
From: Investment Income			111.20
Permanent Science Fund:			
From: Boston Safe Deposit and Trust Co., Trustee		$15,946.62	
Return of balance of Grant		21.03	
Investment Income		47.26	
			16,014.91
Kennelly Fund:			
From: Investment Income			63.36
Total Receipts			$34,308.23

†EXPENDITURES

Academy, General:			
Library, Salaries	$2,048.00		
Books & Binding (Net)	362.58		
		$2,410.58	
General (Net)		861.45	
House (Net)		2,559.46	
President's Office		7.50	
Treasurer's Office		539.35	
Insurance		605.79	
			$6,984.13

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* Excluding sales of securities.
† Excluding purchases of securities.

Amory Fund:		
Expense		$48.00
Publications Committee:		
General	$3,496.72	
Lake	174.39	
		3,671.11
Rumford Fund Committee:		
Grants	$400.00	
To Rumford Fund	720.00	
		1,120.00
Warren Fund Committee:		
Grants		700.00
Mabel S. Agassiz Fund:		
For Meetings		111.20
Permanent Science Fund:		
Grants	$1,585.00	
Expense	1.65	
		1,586.65
Special Expense:		
Recording Secretary		27.40
Total Expenditures		$14,248.49

REPORT OF THE LIBRARY COMMITTEE

In addition to the many volumes and serials consulted at the Academy within the past year, there were borrowings by eighteen outside libraries. Of the total of 87 volumes and 16 unbound numbers borrowed, very few were taken out by Fellows of the Academy, and the inference is not unwarranted that the resources of our Library are perhaps better realized from without than from within our walls.

The addition of 217 volumes since last year's report brings the number on the shelves to 47,114. Of the additions, 153 were received by gift or exchange and 64 were purchased. Most of the items purchased were parts of serial sets from the Library of the Boston Society of Natural History, filling gaps in the Academy sets. The price paid for these was $110. From the general sale of duplicates the Academy has realized $165.

At the Stated Meeting of October 11, 1939, the Corresponding Secretary read an excerpt from the will of the late Arthur E. Kennelly, by the terms of which the Academy was accorded the choice of such volumes from his scientific library as might remain after the fulfillment of certain other bequests. These items have all been inspected and several volumes and pamphlets selected.

With the approval of the Council of the Academy and of the Director of the Massachusetts Historical Society, The Academy's loan of its single volume (1759–60) of the *Boston Post-Boy* was transferred from the Historical Society (there a duplicate) to fill a gap in the newspaper files of the American Antiquarian Society. In requesting this transfer, the Director of the latter society has further proposed the permanent exchange for this item of certain scientific material to be later submitted for approval.

A preliminary survey has been made of the stacks relative to the need for oiling, repair or re-binding of the older volumes. In the absence of appropriation for this purpose it is proposed to spread the work over a time sufficient to place it within current resources.

The appropriation for the year ending March 31, 1943, was $3000, and the expenditure was as follows:

Salaries	$2,048.00
Purchase of books and periodicals	299.93
Binding	227.65
Total	$2,575.58

Respectfully submitted,
FREDERICK H. PRATT, *Librarian*
May 12, 1943.

REPORT OF THE RUMFORD COMMITTEE

Some weeks ago, the chairman of this Committee wrote to thirteen recent recipients of Rumford grants. From four no replies have as yet been received. Of the remaining nine, five report progress and two complete cessation of the research owing to the war. One, for a like reason, suggests the return of the Rumford grant. By one the statement is made that an instrument has been built but that its test has been indefinitely postponed because of war conditions.

A meeting of the Rumford Committee was held January 11, 1943. As there were no applications for grants, the sole topic under discussion was the nomination of the Rumford medalist for 1943. Charles Edward Kenneth Mees was chosen by the five members of the Committee who were present. This nomination was later made unanimous by letters received from the two absentees.

During March a confirmation of this nomination, as required by the statutes, was obtained. The vote was again unanimous.

The Committee, therefore, presented his name to the Academy requesting its approval of the nomination, the medals to be awarded "For his contributions to the science of photography."

Respectfully submitted,
NORTON A. KENT, *Chairman*
May 12, 1943.

REPORT OF THE CYRUS M. WARREN COMMITTEE

The Committee had available for grants during the fiscal year 1942–43 the sum of $900. From this amount the following grants totalling $700 have been made:

To Professor F. F. Nord of Fordham University, New York City, a grant of $300 for the purchase of some rare sugars for use in continuing research in the field of enzyme reaction.

To Dr. Carl C. Smith of the University of Cincinnati, Cincinnati, Ohio, a grant of $400 for materials to be used in the investigation of the chemical properties of angiotonin.

The balance of $200 has been added to the appropriation for the coming year, 1943–44.

A communication was received in May 1942 from Professor Arthur F. Scott reporting on work undertaken with the aid of a grant in 1938. Brief reports were received from Professor J. W. McBain and Dr. Philip Pizzolato in regard to grants received in 1941. Dr. C. C. Smith has reported good progress on his work on the chemical properties of angiotonin.

Reprints have been received on work carried out with the assistance of grants, as follows:

Professor E. C. Gilbert: "The Apparent Energy of the N-N Bond as Calculated from Heats of Combustion" J. Am. Chem. Soc. *24*, 2369 (1942).

Professor Paul L. Kirk: "Microscopy of the Amino Acids and Their Compounds" Ind. and Eng. Chem. *13*, 587 (1941).

Professor G. Krotkov: Report and reprints on "Diurnal Changes in the Carbohydrates of Wheat Leaves" Can. Jour. of Research, *21*, 26 (1943).

Professor F. F. Nord: "Essential Steps in the Enzymatic Breakdown of Hexoses and Pentoses" Archives of Biochemistry, *1*, 143 (1942).

The resignation during the past year of two members of the Committee is reported: that of Professor Reid Hunt and Professor Tenney L. Davis.

Respectfully submitted,
FREDERICK G. KEYES, *Chairman*
May 12, 1943.

REPORT OF THE COMMITTEE OF PUBLICATION

The Committee held one meeting during the year on October 4, 1942. Other business was transacted by correspondence which was necessitated by the absence of the Chairman in Washington.

During the year the following numbers of the *Proceedings* were published: Vol. 74, No. 14. Records of meetings: List of Members: Statutes. Vol. 75, No. 1. Whithead, A. N. and others. Papers on post-war problems. At the present time the following papers are in proof:

1. F. M. Carpenter: The Lower Permian Insects of Kansas. Part 9.
2. Tenney L. Davis and Chao Yün-Ts'ung: Chao Hsüeh-Min's Outline of Pyrotechnics.
3. D. L. Augustine: Some Factors in the Defense Mechanism against reinfection with *Trypanosoma Lewisii.*

A couple of articles were submitted by persons not members of the Academy which were referred to readers in the respective fields, and declined upon receipt of their reports. No other material is at present in the hands of the Editor for publication.

Professor and Mrs. Lake have been actively at work on the Index to *Dated Greek Manuscripts.* Six of the main rubrics in this have been prepared by them and checked by the Editor with the assistance of Drs. Paul J. Alexander and Milton V. Anastos, Junior Fellows at Dumbarton Oaks. The remaining indices are expected to be finished shortly. Owing to illness the Editor has been unable to make arrangements with the Waverly Press for the transfer of the bulk of the remainders of the publication to Boston, but hopes to do so before he leaves Washington in June.

Professor Hatch has been working on the indices to his *Album of Dated Syriac Manuscripts,* and the major part of these have been prepared and sent on to the printer.

The Committee wishes to go on record with an expression of their deep regret at the death of their fellow member, Professor Joseph H. Beale, on January 20, 1943. His collaboration in recent years had been impeded by illness, but his interest remained none the less unflagging and his sound counsel was of great help in various problems which arose.

Respectfully submitted,
Robert P. Blake, *Chairman*

May 12, 1943.

Report of the House Committee

During the year ending March 31, 1943, the House Committee had at its disposal funds amounting to $2,195, made up as follows:

Appropriation for 1942–43	$2,000
Received from other societies for the use of rooms	195
Total	$2,195

The expenditures amounted to $2,754.46. Of this the sum of $2,543.59 was spent for routine expenses and $210.87 for upkeep and equipment.

Meetings have been held as follows:

The Academy	8
Archæological Institute of America, Boston Society	2
Boston Surgical Society	3
New England Botanical Club	9
Total	22

The Council Chamber has been used for Academy Council and Committee meetings, and also by the Trustees of the Children's Museum and the New England Farm and Garden Association.

A detailed list of expenditures follows:

Janitor	$951.00
Electricity: Light	205.01
Power	68.51
Fuel	966.35
Elevator service and repairs	117.96
Telephone	124.47
Gas	50.19
Water	40.48
Upkeep and equipment	210.87
Janitor's supplies and sundries	19.62
Total	$2,754.46

Appended are the revised "Rules for the use of the House," adopted by the Council in May 1942:

RULES FOR THE USE OF THE HOUSE

(Adopted by the Council, May 13, 1942)

Preamble

The Council reserves the right to grant permission to or withhold permission from any organization which may seek to use the House for regular meetings or for more than one meeting in any one calendar year.

Rules

1. The House of the Academy shall be available for the use of Fellows of the Academy at all reasonable hours.

2. Except as otherwise provided, the privilege of using the House of the Academy shall be enjoyed by Fellows only, who shall, however, be permitted to bring guests with them to a number not exceeding twenty.

3. Fellows introducing guests shall be responsible for any injury caused by them to the property of the Academy.

4. Fellows or organizations introduced by them may use the Committee Room and the Reception Room on the ground floor and also the Assembly Hall and the Reading Room. For the use of the rooms on the ground floor no charge shall be made. For the use of the Assembly Hall a charge of $10 will be made for each occasion; for the Reading Room there will be a charge of $15 if no refreshments are served; or $20, if there are refreshments. An additional charge of $5 will be made for each hour or fraction of an hour during which the rooms are occupied after 11 P. M. The House Committee is authorized, however, to reduce the charges for small groups.

5. A visitors' book shall be kept in such place as the House Committee may determine, in which the names of Fellows using the House and the names of their guests, or organizations they introduce, shall be entered.

6. Fellows, or organizations introduced by them, desiring to use either of the two large rooms for a meeting shall make application to the Assistant Librarian not less than one week in advance of the time at which the meetings is to be held.

7. The privileges of the House shall be limited to Fellows and their guests and to learned and cultural societies introduced by Fellows, ap-

proved by the House Committee, and endorsed by the Council. Societies not on the approved list should make written application to the Assistant Librarian at least two weeks in advance of the proposed meeting, and in any event sufficiently in advance to permit of action by the Council.

Respectfully submitted,
E. F. Langley, *Chairman*

May 12, 1943.

Mr. Edmund A. Whitman spoke of the need of greater maintenance expenditure, particularly on the heating and ventilating system, which is obsolete and in poor condition. It was *Voted,* that the problem be referred to the Policy Committee, with the suggestion that the desirability of increasing the annual dues be considered.

A motion was made that the annual dues for Fellows resident within the fifty mile radius be set at ten dollars for the year 1943–44. Mr. Whitman proposed to postpone action on dues until the report of the Policy Committee. After brief discussion the amendment was withdrawn and the original motion was carried.

On the recommendation of the Rumford Committee it was *Voted,* to award the Rumford Medals to Charles Edward Kenneth Mees for his contributions to the science of photography.

The following officers and committees were elected for the coming year:

Harlow Shapley, *President*
Percy W. Bridgman, *Vice-President for Class I*
S. Burt Wolbach, *Vice-President for Class II*
Sidney B. Fay, *Vice-President for Class III*
Fred N. Robinson, *Vice-President for Class IV*
Abbott P. Usher, *Corresponding Secretary*
Hudson Hoagland, *Recording Secretary*
Horace S. Ford, *Treasurer*
Frederick H. Pratt, *Librarian*
Robert P. Blake, *Editor*

Councillors for Four Years:

John M. Lessells, of Class I
Charles A. Weatherby, of Class II
Robert G. Caldwell, of Class III
Kenneth J. Conant, of Class IV

Councillor for Three Years:

Calvert Magruder, of Class III

Councillor for Two Years:

Donald S. Tucker, of Class III

Committee on Policy and Resources:

Robert G. Dodge, *Member for Five Years*

Finance Committee:

Jerome C. Hunsaker
John F. Ebersole
Ralph E. Freeman
Henry P. Kendall

Rumford Committee:

Norton A. Kent, *Chairman*

Percy W. Bridgman
George W. Pierce
Harry M. Goodwin
George R. Harrison
Harlow Shapley
Robert B. Lindsay

C. M. Warren Committee:

Frederick G. Keyes, *Chairman*

Gregory P. Baxter
Grinnell Jones
Walter L. Jennings
Avery A. Morton
Charles A. Kraus
Walter C. Schumb

Committee of Publication

Robert P. Blake, *Chairman*

Edwin C. Kemble, of Class I
Ralph H. Wetmore, of Class II
Arthur H. Cole, of Class III
Robert P. Casey, of Class IV

Committee on the Library:

Frederick H. Pratt, *Chairman*

Raymond C. Archibald, of Class I
Thomas Barbour, of Class II
Francis N. Balch, of Class III
Henry B. Washburn, of Class IV

Auditing Committee:

Erwin H. Schell
Alexander Forbes

House Committee:

Ernest F. Langley, *Chairman*

H. Addington Bruce
Robert P. Bigelow
Walter E. Clark

Committee on Biographical Notices:

Three Years:

Raymond C. Archibald
Samuel E. Morison

Two Years

Austin W. Scott

Committee on Meetings:

THE PRESIDENT

THE RECORDING SECRETARY

LEONARD CARMICHAEL GEORGE SCATCHARD
SAMUEL H. CROSS FREDERICK K. MORRIS

Three communications were then presented:

George Sarton: "Copernicus."

Fred L. Whipple: "The Solar System."

Bart J. Bok: "The Milky Way and the Metagalaxy."

Some original editions of the works of Copernicus, loaned by the Harvard College Library, were on exhibition in the office.

The meeting was dissolved at 10.25 P. M.

One Thousand Two Hundred and Eighty-eighth Meeting

OCTOBER 13, 1943—STATED MEETING

The Academy met at its House at 8.20 P. M.

The President in the Chair.

There were present fifty-two Fellows and forty-three guests.

The records of the meeting of May 12 were read and approved.

The Corresponding Secretary reported the receipt of letters accepting Fellowship from the following: Leonard Bacon, Arlie Vernon Bock, Augusta Fox Bronner (Mrs. William Healy), Willa Cather, Ada Louise Comstock (Mrs. Wallace Notestein), David Bruce Dill, Angus Dun, Philipp Frank, Hugh O'Neill Hencken, Chester Scott Keefer, Edwin Herbert Land, Lewis Don Leet, Brenton Reid Lutz, Cecilia Payne Gaposchkin, Benjamin Morris Selekman, Jean Joseph Seznec, Donald Charles Stockbarger, Hugh Stott Taylor, Randall Thompson, Payson Sibley Wild, Jr., and Charles Edward Wyzanski, Jr.

He also reported the receipt of a letter from Henry I. Harriman resigning Fellowship, to take effect in May 1944.

The Rumford medals were then presented to Dr. Charles Edward Kenneth Mees for his contributions to the science of photography.

Dr. Mees made an address on "Sensitizing Dyes and Their Use in Photography," which was illustrated with lantern slides as well as a practical demonstration.

The meeting was dissolved at 10.00 P. M.

One Thousand Two Hundred and Eighty-ninth Meeting

NOVEMBER 10, 1943—STATED MEETING

The Academy met at its House at 8.25 P. M.

The President in the Chair.

This meeting had been designated as Ladies' Night, and there were present about 180 Fellows and guests.

The records of the meeting of October 13 were read by the Corresponding Secretary in the absence of the Recording Secretary, and approved by the Academy.

The Corresponding Secretary reported the acceptance of his election as a Fellow by Perry Gilbert Eddy Miller.

Professor Martin Wagner and Mr. Hermann Herrey addressed the Academy on "The Future of Our Cities." There were lantern slide illustrations, and a special exhibition in the Reading Room, arranged by Mr. Herrey.

The meeting was dissolved at 10.15 P. M.

One Thousand Two Hundred and Ninetieth Meeting

DECEMBER 8, 1943—STATED MEETING

The Academy met at its House at 8.20 P. M.

The President in the Chair.

There were present fifty-five Fellows and twenty-five guests.

The records of the meeting of November 10 were read and approved.

The following communication was presented:

Frederick K. Morris: "European Topography and the Progress of the Allied Armies," illustrated with lantern slides and maps.

The meeting was dissolved at 9.45 P. M.

One Thousand Two Hundred and Ninety-first Meeting

JANUARY 12, 1944—STATED MEETING

The Academy met at its House at 8.28 P. M.

The President in the Chair.

There were present fifty-three Fellows and fifty guests.

In the absence of the Recording Secretary, his duties were assumed by the Corresponding Secretary.

The records of the meeting of December 8 were read and approved.

The Corresponding Secretary reported a proposed amendment to the Statutes, which had been approved by the Council, as follows:

Chapter II, Article 1, paragraph 1, to read as follows: "The Academy shall consist of Fellows, elected from the citizens or residents of the United States of America, Fellows Emeriti, and Foreign Honorary Members. They shall be arranged in four Classes, according to the Arts and Sciences in which they are severally proficient and each Class shall be divided into four Sections, namely:"

The Academy voted to amend the Statutes as recommended by the Council.

The following communications were presented: T. North Whitehead and Warren A. Seavey: "How Should Post-War Germany Be Treated?"

The meeting was dissolved at 10.23 P. M.

One Thousand Two Hundred and Ninety-second Meeting

FEBRUARY 9, 1944—STATED MEETING

The Academy met at its House at 8.30 P. M.

The President in the Chair.

There were present fifty-seven Fellows and thirty guests.

The records of the meeting of January 12 were read and approved.

A letter from Boston University was read inviting the members of the Academy to attend the sessions of an Institute on Post-War Problems which the University is planning to hold in connection with its Founder's Day observance, March 11, 12 and 13.

The following communication was presented: Jerome C. Hunsaker: "Aeronautical Research," illustrated with lantern slides and motion pictures.

There was also an exhibit of astronomical slides by Dr. Shapley to illustrate recent astronomical discoveries.

The meeting was dissolved at ten o'clock.

One Thousand Two Hundred and Ninety-third Meeting

MARCH 8, 1944—STATED MEETING

The Academy met at its House at 8.25 P. M.

The President in the Chair.

There were present thirty-nine Fellows and twelve guests.

The records of the meeting of February 9 were read and approved.

The Corresponding Secretary reported the receipt of a letter from Bradley Dewey accepting his election to Fellowship.

On the recommendation of the Council the following appropriations were made for the ensuing year:

From the income of the General Fund, $7225, to be used as follows:

for House expenses	$2,600
for General and Meeting expenses	1,000
for Library expenses	2,625
for Treasurer's expenses	1,000
	$7,225

From the income of the Publication Funds, $2,144, to be used for publication.

From the income of the Rumford Fund, $3111, to be used at the discretion of the Committee.

From the income of the C. M. Warren Fund, $870, to be used at the discretion of the Committee.

The President announced the appointment of the Nominating Committee:

Dugald C. Jackson, of Class I, *Chairman*
Robert P. Bigelow, of Class II
Henry P. Kendall, of Class III
William C. Greene, of Class IV

He reported the discovery, through the calculations of Mr. Clemence of the U. S. Naval Observatory, that the orbit of the Earth rotates in space in accordance with the Einsteinian theory of relativity. Heretofore the "advance of the longitude of the perihelion" of a planetary orbit was known for Mercury only.

The following communication was presented: John H. Williams: "Post-War Currency Stabilization."

After the address by Dean Williams the President reported on a special exhibit of a new kind of "fishing frog"—a sort of deep sea monster called *Reganichthys giganteus* nov. gen. et sp., by Fellows H. B. Bigelow and Thomas Barbour, who have recently procured this unusual fish from a fisherman off the Maine coast. It belongs to the group called *Ceratioids*.

The meeting was dissolved at 10.15 P. M.

One Thousand Two Hundred and Ninety-fourth Meeting

APRIL 12, 1944—STATED MEETING

The Academy met at its House at 8.30 P. M.

The President in the Chair.

There were present twenty-nine Fellows and twenty-four guests.

The records of the meeting of March 8 were read and approved.

The Corresponding Secretary announced that the Council had made the following grants from the Permanent Science Fund:

1. To Theodor von Brand and W. Gardner Lynn, Catholic University of America, Washington, D. C., for special equipment for use in investigation of metabolic rates in turtle embryos, $80.
2. To Curtis L. Newcombe, Associate Professor of Biology, College of William and Mary, Williamsburg, Va., for assistance in a further study of the larval stages of *Volsella demissus*, the ribbed mussel, a source of food, $600.00.
3. To Frances A. Schofield, Adjunct Professor of Chemistry, Randolph Macon Woman's College, Lynchburg, Va., to provide assistance and expendable materials in a further study of glycogen forming activity of alanine isomers, $500.
4. To Abraham M. Shanes, Instructor in Physiology, New York University, College of Dentistry, for assistance in extending a study of bioelectric potentials, $450.

The President discussed plans for Academy coöperation next year with the Institute of Religious and Social Studies, as considered earlier in the evening by the Council.

The following communication was presented:

Frederick Fuller Russell: "The War and Public Health."

The meeting was dissolved at ten o'clock.

One Thousand Two Hundred and Ninety-fifth Meeting

May 10, 1944—Annual Meeting

The Academy met at its House at 8.25 P. M.

The President in the Chair.

There were present forty-eight Fellows and thirty guests.

The records of the meeting of April 12 were read and approved.

The Corresponding Secretary reported that Arturo Rosenblueth had resigned his Fellowship.

He then read the annual report of the Council:

Report of the Council

Since the last report of the Council there have been reported the deaths of thirty-three Fellows: Joseph Sweetman Ames, Charles McLean Andrews, Edward Cooke Armstrong, Charles Macfie Campbell, James McKeen Cattell, Russell Henry Chittenden, Winthrop More Daniels, Charles Benedict Davenport, William Johnson Drisko, Arthur Fairbanks, Albert Bushnell Hart, Aleš Hrdlička, Douglas Wilson Johnson, Arthur Keith, Alexander George McAdie, Lee Sullivan McCollester, Edward Bennett Mathews, William Cardinal O'Connell, Robert Ezra Park, William Lyon Phelps, James Bissett Pratt, Henry Washington Prescott, Alfred Lawrence Ripley, William Emerson Ritter, Frank Schlesinger, James Brown Scott, Henry Lloyd Smyth, John Frank Stevens, John Stone Stone, Robert Spurr Weston, Joseph Ruggles Worcester, David Elbridge Worrall, Karl Young; and two Foreign Honorary Members: Sir William Searle Holdsworth and Sir Aurel Stein.

The following Fellows have been classified as Fellows Emeriti: Edward B. Hill (Mar. 8, 1944), William E. Hocking (Nov. 10, 1943), Carl N. Jackson (Apr. 20, 1943), John L. Lowes (Feb. 9, 1944) and Edward K. Rand (Dec. 9, 1942).

Twenty-seven Fellows were elected by the Council and announced to the Academy in May 1943.

The roll now includes 759 Fellows, five Fellows Emeriti, and 117 Foreign Honorary Members (not including those elected in May 1944).

The reports of the Treasurer and of the standing committees, which follow, were not read to the Academy but to the Council at its meeting preceding the Academy meeting. A summary of them was, however, given by the President:

Report of the Treasurer

*Receipts

Academy, General:			
From: Investment Income	$12,747.65		
Less: Income to Special Funds	10,064.66		
		$2,682.99	
Assessments and Admission Fees		4,210.00	
			$6,892.99
Amory Fund Committee:			
From: Investment Income			3,155.51

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[*] Excluding sales of securities.

Publications Committee:		
From: Investment Income	$2,281.60	
Sale of Publications	787.92	
Contribution	5.00	
Lake Publication, from American Council Learned Societies	2,500.00	
		$5,574.52
Rumford Fund Committee:		
From: Investment Income	$3,113.50	
Return of Grant	400.00	
		3,513.50
Warren Fund Committee:		
From: Investment Income		925.95
Mabel S. Agassiz Fund:		
From: Investment Income		106.40
Permanent Science Fund:		
From: Boston Safe Deposit and Trust Co., Trustee	$9,949.74	
Return of balance of Grant	7.72	
Investment Income	417.70	
		10,375.16
Kennelly Fund:		
From: Investment Income		64.00
Total Receipts		$30,608.03

*Expenditures

Academy, General:			
Library, Salaries	$2,036.00		
Books & Binding	651.84		
		$2,687.84	
General (Net)		1,234.32	
House (Net)		2,524.35	
Treasurer's Office		570.07	
Insurance		589.70	
			$7,606.28
Amory Fund:			
Expense			53.00
Publications Committee:			
General		$898.87	
Lake		267.27	
			1,166.14
Rumford Fund Committee:			
Grants		$650.00	
Medal		350.04	
			1,000.04
Warren Fund Committee:			
Grants			250.00
Mabel S. Agassiz Fund:			
For Meetings			106.40
Permanent Science Fund:			
Grants		$1,050.00	
Expense		4.93	
			$1,054.93
Special Expense:			
Recording Secretary			1.91
Total Expenditures			$11,238.70

Report of the Library Committee

During the year 1943–44, fifty-three volumes and sixteen unbound numbers of serials were borrowed by eight Fellows and nineteen libraries, and many more have been consulted at the Academy.

The number of volumes on the shelves at the time of the last report was 47,114. During the year 147 bound volumes were added, making the number now 47,261. Of this number 134 were received by gift or exchange, and 13 were purchased. To these are to be added a number of unbound volumes, parts of serial publications, and pamphlets, none of which are counted as volumes until they are bound.

From the American Antiquarian Society came a generous contribution of 14 bound volumes, 89 unbound volumes or numbers of serials, and a large number of pamphlets in exchange for our single volume of the *Boston Post-Boy* (1759–60), transferred as a duplicate by its borrower, the Massachusetts Historical Society, to complete the Antiquarian Society's valuable file.

The appropriation for the year ending March 31, 1944, was $2,625, the expenditures being as follows:

Salaries	$2,036.00
Purchase of books and periodicals	463.84
Binding	188.00
Total	$2,687.84

For the conservation of bindings, a special appropriation has been voted by the Council. In expectation of this initial grant of $100 expert advice and service have been obtained relative to oiling and repair. Of particular concern are the leather bindings of many treasured items, such as early volumes of the *Philosophical Transactions* and books belonging to the original bequest of Governor Bowdoin, the Founder, as well as the ancient works bearing the bookplate of President John Adams and other early Fellows.

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* Excluding purchases of securities.

Just as our rich files of modern serials and transactions in the physical sciences should attract the investigator who appreciates convenience of reference and ease of withdrawal, so our long-since static collection of 18th and 19th-century published books should have no small appeal for the antiquary who seeks to know what the Academy in the course of its first century saw fit to collect; for, in a sense not wholly figurative, they reflect the atmosphere our learned forerunners are presumed to have breathed.

Respectfully submitted,
FREDERICK HAVEN PRATT, *Librarian*
May 10, 1944.

REPORT OF THE RUMFORD COMMITTEE

During the past Academy year, but two grants have been made by the Rumford Committee. The first one, July 20, 1943, was made to Dr. Alvin H. Nielsen of the University of Tennessee for $350 for the purchase of a rock salt prism and four pairs of rock salt windows to be used in his study of the vibration-rotation bands of certain polyatomic molecules. The second grant was made on March 11, 1944, to Professor Richard H. Goodwin of the University of Rochester for $300 for the purchase of a Kleet Fluorimeter-Colorimeter and certain accessories to be used in his studies on the effect of light upon the development of pigments in plants. Both these grants were made through correspondence and personal conferences between the members of the Committee and the Chairman. Because of war conditions, no letters were sent out asking for reports of the progress being made by previous grantees.

On October 13, 1943, the Rumford Medals were presented to Dr. Charles Edward Kenneth Mees for his contributions to the science of photography.

Respectfully submitted,
NORTON A. KENT, *Chairman*
May 10, 1944.

REPORT OF THE CYRUS M. WARREN COMMITTEE

The Committee had available for grants during the fiscal year 1943–44 the sum of $950, of which $750 was appropriated at the March 1943 meeting and $200 remained as a balance from the previous year, 1942–43. From this amount two grants were made totalling $400, as follows:

To Professor Thomas W. Davis of New York University, a grant of $150 for the purchase of a Lecky-Ewell type of fractionating column and accessory equipment for use in analyzing mixtures of hydrocarbons.

To Doctor Walter J. Nickerson of Wheaton College, Norton, Massachusetts, a grant of $250 to defray the expense of obtaining improved manometric equipment for use in studies on cellular respiration and for reagents to be used in attempts to synthesize possible intermediate compounds in the oxidation of acetate and ethanol.

A report has been received from Professor Davis in the form of a letter in which he states that by the time he was able to place an order for a Lecky-Ewell fractionating column, it was no longer possible to obtain one. He has since then investigated the next best procedure and finds that additional funds will be needed to secure any other type of column. He is therefore holding the grant awaiting the opportunity to secure additional funds.

A report from Doctor Nickerson indicates that only a small portion of his grant has been used inasmuch as he has been in the Army for some time. The unused balance of his grant is being held till such time as he can resume his research, and further reports will then be submitted. Two publications have been completed and reprints will be sent as soon as they are received from the printer.

Reprints have beeen received as follows, covering work assisted by grants:

Professor E. C. Gilbert: "The Apparent Energy of the N-N Bond as Calculated from Heats of Combustion," C. M. Anderson and E. C. Gilbert, J. Am. Chem. Soc., *24*, 2369 (1942).

Professor F. F. Nord: "On the Mechanism of Enzyme Action. Part 21. Intermediary Phases in the Enzymatic Breakdown of d, l-Alanine by Fusarium lini Bolley." John C. Wirth and F. F. Nord, Archives of Biochemistry, *2*, 463 (1943).

Respectfully submitted,
FREDERICK G. KEYES, *Chairman*
May 10, 1944.

REPORT OF THE COMMITTEE OF PUBLICATION

The Publication Committee held one meeting on October 6, 1943, other business having been transacted by correspondence.

Dated Greek Manuscripts. Professor and Mrs. Lake have been busily engaged upon the Index to the ten fascicles which have appeared and have submitted all of the thirteen indices and a large part of the prefatory material to the editor. The greater part of this is now in proof, and it is hoped that the index volume can appear by the fall.

In June, 1943, the remainders of the set were transported by truck from Baltimore and stored in the Academy's House. The total cost of this operation amounted to about $160 and will represent an annual saving in insurance charges of $119.40. The Waverley Press has kept a certain number of sets on hand, and the store will be replenished from time to time as sales occur.

Album of Dated Syriac Manuscripts. All the material is in the hands of the printer, and all galley proof has been corrected, but there has been some delay in receiving the page proof. It is hoped that this will appear shortly, and the book can then come out in the fall. Arrangements have been made with the Harvard University Press to handle the sales of the publication which have been approved by the President and the Treasurer.

One article by Professor S. J. Barnett of the University of California at Los Angeles has been accepted and page proof is now in the Editor's hands. It is entitled "New Researches on Magnetization by Rotation and the Gyromagnetic Ratios of Ferromagnetic Substances."

A *Records* number of the Proceedings will be published this fall which will also contain the remainders of the memoirs on deceased Fellows whose publication has been perforce delayed.

Respectfully submitted,
Robert P. Blake, *Editor*

May 10, 1944.

Report of the House Committee

During the year ending March 31, 1944, the House Committee has had at its disposal funds amounting to $2,450, as follows:

Appropriation for the year 1943–44	$2,200
Received from other societies for the use of rooms	250
Total	$2,450

The expenditures amounted to $2,774.35. Of this the sum of $2,415.76 was spent for the routine expenses, janitor, heat, light, telephone, etc. and $358.59 for upkeep, furnishings and equipment. The most important item in the latter category was $188, paid for putting back into working order an automatic heating and ventilating control system, which was installed when the house was built, but which had not been used for a number of years. Repairs to the elevator cost $150.53.

Meetings have been held as follows:

The Academy	8
Archæological Institute of America, Boston Chapter	1
Architectural Society of M. I. T.	1
Boston Surgical Society	2
Institute of Food Technologists	7
Lowell Institute Alumni	1
New England Botanical Club	9
Total	29

The Council Chamber has been used for the Academy Council and Committee meetings, and also by the Trustees of the Children's Museum and the New England Farm and Garden Association.

A detailed list of the expenditures follows:

Janitor	$967.00
Fuel	840.38
Elevator service and repairs	222.53
Electricity: Light	192.79
Power	44.20
Telephone	137.89
Gas	53.63
Water	47.84
Upkeep, furnishings and equipment	208.06
Janitor's supplies and sundries	60.03
Total	$2,774.35

The deficit of $324.35 will be met by transfer from the General Fund.

Respectfully submitted,
Ernest F. Langley, *Chairman*

May 10, 1944.

The President announced that he had appointed a committee to cooperate with the committee of the Institute of Religious and Social Studies, consisting of E. S. Brightman, *Chairman,* the President of the Academy, A. D. Nock, and the Chairman of the House Committee.

On the recommendation of the Treasurer, the Academy voted that the annual assessment for the year 1944–1945 for resident Fellows be ten dollars.

The annual election of officers and committees resulted as follows:

Howard M. Jones, *President*
George R. Harrison, *Vice-President for Class I*
Alfred C. Lane, *Vice-President for Class II*
Ralph E. Flanders, *Vice-President for Class III*
Fred N. Robinson, *Vice-President for Class IV*
Abbott P. Usher, *Corresponding Secretary*
Hudson Hoagland, *Recording Secretary*
Horace S. Ford, *Treasurer*
Frederick H. Pratt, *Librarian*
Robert P. Blake, *Editor*

Councillors for Four Years:

Gustavus J. Esselen, of Class I
Chester S. Keefer, of Class II
Laurence L. Winship, of Class III
Warren O. Ault, of Class IV

Councillor for One Year:

Hyder E. Rollins, of Class IV

Committee on Policy and Resources:

Member for Five Years and Chairman:

Harlow Shapley

Finance Committee:

Jerome C. Hunsaker
Ralph E. Freeman
Henry P. Kendall
John F. Ebersole

Rumford Committee:

Norton A. Kent, *Chairman*
Percy W. Bridgman
George R. Harrison
Harry M. Goodwin
Robert B. Lindsay
Harlow Shapley
Francis O. Schmitt

C. M. Warren Committee:

Frederick G. Keyes, *Chairman*
Gregory P. Baxter
Grinnell Jones
Walter L. Jennings
Avery A. Morton
Charles A. Kraus
Walter C. Schumb

Committee of Publication:

Robert P. Blake, *Chairman, ex officio*
Edwin C. Kemble, of Class I
Ralph H. Wetmore, of Class II
Arthur H. Cole, of Class III
Robert P. Casey, of Class IV

Committee on the Library:

Frederick H. Pratt, *Chairman, ex officio*
Raymond C. Archibald, of Class I
Thomas Barbour, of Class II
Francis N. Balch, of Class III
Henry B. Washburn, of Class IV

Auditing Committee:

Erwin H. Schell
Alexander Forbes

House Committee:

Charles M. Spofford, *Chairman*
H. Addington Bruce
Robert P. Bigelow
Donald S. Tucker

Committee on Biographical Notices:

Three Years

Abbott P. Usher, *Chairman*
Leigh Hoadley

Committee on Meetings:

The President
The Recording Secretary
Leonard Carmichael
Jerome D. Greene
Abbott P. Usher
Frederick K. Morris

The Corresponding Secretary announced that the following had been elected members of the Academy:

FELLOWS

Class I

Section 1. Saunders MacLane, Cambridge
John von Neumann, Princeton, N. J.
Section 2. Ronold Wyeth Percival King, Winchester
Section 3. Isadore Amdur, Cambridge
Linus Carl Pauling, Pasadena, Cal.
Edgar Bright Wilson, Jr., Cambridge
Section 4. Arthur Robert von Hippel, Weston
Richard von Mises, Cambridge
Karl Terzaghi, Winchester

Class II

Section 1. Columbus O'Donnell Iselin, II, Woods Hole
Harald Ulrik Sverdrup, La Jolla, Cal.
Section 2. Paul Rupert Gast, Petersham
Hugh Miller Raup, Jamaica Plain
Albert Charles Smith, Jamaica Plain
Section 3. Eugene Markley Landis, Brookline

Section 4. Maxwell Finland, Boston
William Malamud, Worcester
George Widmer Thorn, Cambridge

Class III

Section 2. Vera Micheles Dean, New York, N. Y.
Carl Joachim Friedrich, Concord
Sarah Wambaugh, Cambridge
Section 3. Douglass Vincent Brown, Brookline
Section 4. Adolf Augustus Berle, Jr., Washington, D. C.
Raymond Blaine Fosdick, New York, N. Y.
Ernest Martin Hopkins, Hanover, N. H.
James Rhyne Killian, Jr., Wellesley Hills
Beardsley Ruml, New York, N. Y.
Leverett Saltonstall, Chestnut Hill
Charles Edward Wilson, New York, N. Y.

Class IV

Section 2. William Bell Dinsmoor, New York, N. Y.
Clyde Kay Maben Kluckhohn, Cambridge
Ambrose Lansing, New York, N. Y.
Section 3. Henry Grattan Doyle, Washington, D. C.
Elias Avery Lowe, Princeton, N. J.
La Rue Van Hook, New York, N. Y.
Section 4. Walter Gropius, Lincoln
Charles Rufus Morey, Princeton, N. J.
Karl Vietor, Cambridge
Herbert Eustis Winlock, New York, N. Y.

FOREIGN HONORARY MEMBERS

Class II

Section 1. Ezequiel Ordoñez, Mexico, D. F.

Class III

Section 1. Victor Andrés Belaúnde, Lima, Peru
Section 3. Daniel Cosío Villegas, Mexico, D. F.

Class IV

Section 3. Amado Alonso, Buenos Aires, Argentina

The following communication was presented:

Sarah Wambaugh: "The Place of the Small State in Organization for Peace."

Dr. Francis O. Schmitt exhibited a selection of electron microscope pictures of biological specimens.

The meeting was dissolved at 10.35 P. M.

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FRANCIS GREENLEAF ALLINSON
(1856–1931)

Fellow in Class III, Section 2, 1914

Francis Greenleaf Allinson was born at Burlington, N. J., Dec. 16, 1856 and died at his summer home, Hancock Point, Me., June 23, 1931. He was a son of the Quakers, William James and Rebecca Webb (Hinchman) Allinson, and a great-great-grandson of Joseph Allinson who came from Yorkshire, England to Burlington in 1718. His father, a drug merchant and for many years the editor of *The Friends Review* of Philadelphia, was a close personal friend of the poet Whittier in anti-slavery times, and the son Francis was given the poet's middle name. Less than six months later Whittier published a poem, "My namesake."[1]

Francis entered Haverford College and graduated A.B. in 1876 and A.M. in 1879. After a year at Harvard he received the degree of A.B. there also in 1877. He then had the wonderful experience of spending three years as fellow in Greek at The Johns Hopkins University in part of the most glorious period of its history, and became a pupil of the great Gildersleeve. When the University was opened in 1876 President Gilman assigned Gildersleeve to an empty room and told him to "radiate." The effect of this radiation in Allinson's case was magical, and after a distinguished career he was naturally selected as Gildersleeve's biographer by the editors of the *Dictionary of American Biography*. He received his Ph.D. at Johns Hopkins in 1880 for a dissertation "On Ionic forms in the second century" (*Amer. Jl. Philol.*, v. 7).

He was successively assistant professor of Latin and Greek at Haverford College (1880–82), headmaster of classics at the University School for Boys, Baltimore, Md. (1882–91), and associate professor of Greek and Latin at Williams College (1892–95). In 1895 he joined the faculty of Brown University as associate professor of Greek and classical philology. He became the professor of classical philology (1898–1915), and was professor of Greek literature and history from 1915 until his retirement as professor emeritus in 1928. During 1910–11 he represented Brown University as the professor at the American School of Classical Studies in Athens, and for many years he served as a member of the managing committee of that School. During the last five months of 1917 he was Sather lecturer on classical literature at the University of California.

Allinson's many articles, biographical sketches and reviews are to be found in such periodicals as *American Journal of Philology*, *Classical Journal*, *Classical Philology*, *Classical Weekly*, *Education*, *Transactions and Proceedings* of the American Philological Association, *Harvard Studies in Classical Philology*, *The Review* (N. Y.), *Nation*, *Century Magazine*, *The Brown Magazine*, *Brown Alumni Monthly*, *Haverfordian*, and *Quaker Alumnus*, Philadelphia. Allinson was an ideal writer of reviews, where his wide knowledge and keen sense of humor were often in evidence. He contributed also to the *Studies in Honor of Basil Lanneau Gildersleeve* (1902), to the *Goodwin Volume of Harvard Studies in Classical Philology* (1901), and the articles on "Albert Harkness" and "John Larkin Lincoln," to the *Dictionary of National Biography*.

His first book was *Rules of Latin Syntax* (Baltimore, 1883) and his second book, *Greek Prose Composition*, went through three editions (Boston, 1890–95). Allinson was long a student and lover of the witty Lucian and brought out a school edition (1905) of *Selections* from his writings. Then in 1926 his *Lucian—Satirist and Artist* appeared in "Our Debt to Greece and Rome" series. Admirable features, as well as defects, in this work have been set forth by L. E. Lord (*Classical Journal*, v. 23, 1928, p. 548–549) and by A. S. Owen (*Classical Review*, v. 41, 1927, p. 179).

Perhaps Allinson's most important contribution to scholarship was his edition of the principal fragments of *Menander* for the Loeb Classical Library (1921). It summarized all of his work in this field. No other classical author was previously so inaccessible to the student of Roman comedy in an English edition as Menander, but here the modern problem was not only to prepare a definitive text, but also translation and commentary. The result was a worthy addition to the Loeb series by one of the best living authorities on Menander.

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[1] This appeared in *Harpers Weekly*, May 13, 1857, vol. 1, p. 323; there are 42 stanzas with four lines in each stanza. *The Friends Review* for June 27, 1857, contains "To J. Greenleaf Whittier. The namesake's response," signed "Greenleaf." This was unquestionably written by the father.

Professor Allinson was twice married,—first, in 1885, to Mary Irwin Carey of Baltimore, who died in 1901 leaving one daughter; and second, in 1905, to Anne Crosby, daughter of Lucilius Alonzo Emery, chief justice of the supreme court of the state of Maine. The second Mrs. Allinson was also a classical scholar and a remarkable woman of great intellectual brilliance. She was dean of women and assistant professor of classical philology at the University of Wisconsin 1892–1900 and dean of the Women's College at Brown University 1900–1905. Besides being the author of a number of books and articles of her own, she collaborated with her husband in *Greek Lands and Letters* (1909) of which there were later editions in 1922 and 1931. They edited also an edition of John Conington's English translation of Virgil's Aeneid (Chicago, 1916, 1923).

Their home was a recognized center of friendly discussion and intellectual interchange, and their brilliant and witty conversation was a source of exhiliration to every visitor. Professor Allinson possessed something of the delicacy of the Hellenic attitude which seemed to influence his manner and way of thinking. He was ever courteous and considerate though he could be vehement in his criticisms of policies and tendencies he did not approve. He wrote of Gildersleeve, "As in his more personal teaching, where a 'mistake' was a 'crime,' so in the wider sweep of his seminary courses an ineluctable exactitude prevailed. No vagueness was acceptable." Every word of this might also be applied to Allinson. He was a very inspiring teacher. He taught his students to form definite opinions. Enthusiasm, great stores of learning at instant command, humor, delight in the specially happy phrase of a translation, and breadth of view which recognized the great importance of fields of knowledge unrelated to his own, made every class-room meeting stimulating.

He was much sought as a lecturer and as a reader of his translations from the Greek. For example, at Brown University in 1917 his subjects were, "Aeschylus: seven against Thebes,—national patriotism"; "Plato: Republic, the universal commonwealth"; "The Greek anthology: selected epigrams,—from Greek democracy to Byzantine imperialism." Similarly in 1920, "Selections from Lucian, films from a second century kodak"; "The Eumenides—The construction of conscience." Of his many other lectures we may refer simply to his Phi Beta Kappa oration on "Daedalus" at Smith College in 1928.

Among other expressions of recognition of his eminence, we may note his election as a fellow of this Academy (1914), as president of the American Philological Association (1921–22), his repeated election as Trustee of the Providence Public Library (1904–31), his receipt of honorary degrees, Litt.D. conferred by the University of Wisconsin (1922) and also by Trinity College (1922), and LL.D. by Haverford College (1931).

He was a graceful writer and a sparkling satirist, fastidious in his criticism and generous in his praise. Unassuming by instinct Professor Allinson left his mark of sincerity and genuineness upon a broad circle of acquaintances. One may appropriately close with Allinson's own translation of six lines of Schiller's "Die Ideale" rehearsing the two elements, "friendship" and "creative work" which had given most value to the poet's life, as well as to his own. "The closing lines," writes Allinson, "have always seemed to me the perfect picture of the scholar's ideal, however conscious he may be that he falls short of the goal."

Creative work that resteth never
That ne'er destroys, but through *slow* ages
Still adding grain to grain, forever
Eternity's vast structure rears
Yet from the debt on Time's great pages
Doth cancel minutes, days and years.

R. C. Archibald

CHARLES BARROIS (1851–1939)

Foreign Honorary Member in Class II, Section I (1915) 1919

Professor Charles Barrois, of Lille, for half a century eminent among the geologists of Europe, was one of the ablest and most illustrious investigators and teachers in the field of the earth sciences that France has produced.

Born at Lille, on April 21, 1851, into one of the great industrial families of northern France, Charles Barrois chose to use his energy and talent in scientific work, rather than in business. When twenty years of age he decided to become a geologist. A few years later he became assistant to Professor Jules Gosselet in the Department of Geology which had just been organized at the University of Lille. He soon began to publish on a variety of geological and paleontological subjects. In one of his earlier papers, for which he was awarded a doctorate of science at the Sorbonne, he made a very useful correlation of the Upper Cretaceous faunal zones of England and Ireland with those of France which has stood the test of time and helped to establish his reputation for careful and thorough stratigraphic work.

During his long and active life more than 150 papers, some of them memoirs of great scientific value, flowed from his pen. They dealt with many branches of the earth sciences—invertebrate and vertebrate paleontology, Cambrian to Quaternary stratigraphy, structural and areal geology, petrology, seismology, and economic geology. Most of them were based on studies of the rocks and fossils of France, but some of the most important of them related to the stratigraphy and paleontology of Spain, and Great Britain. Many of them were descriptions of the geology of areas covered by sheets of the Carte Géologique de la France, which were prepared for, and published by, the Geological Survey of France. The majority of these areas were in Normandy and Brittany, and some of Barrois' most important contributions to science related to the geology and paleontology of those provinces.

But Charles Barrois will be best remembered for his studies of the coal fields of the Nord and of Pas-de-Calais and for the great collection of rocks and fossils from the Carboniferous strata of those regions, and of models showing the geological structure of those beds, which he placed in the Musée Houiller of the University of Lille. He had been largely responsible for the establishment of this museum in 1908. In 1902 he had been made head of the Department of Geology of the University, and the museum will remain as a monument to the work which he did to make that department known throughout the world as a center for teaching and research on the geology and paleontology of coal.

The high quality of Barrois' scientific work was widely recognized by his contemporaries. He was a Commander of the Legion of Honor, a member of the Academy of Sciences of Paris and at one time its president, a foreign member of the Royal Society of London and of the Royal Society of Edinburgh, a member of the Pontifical Academy, a foreign fellow of the Geological Society of London, a foreign correspondent of the Geological Society of America and a foreign member of societies and academies in Belgium, Germany and Spain.

Professor Barrois died on November fifth, 1939, at the age of ninety-one. He is buried in Lille, where he labored so effectively in his chosen field for almost seventy years.

B. F. Howell

CHARLES VALUE CHAPIN (1856–1941)

Fellow in Class II, Section 4, 1914

Dr. Charles Value Chapin, who was born in Providence, Rhode Island, on January 17, 1856, died at his home on Keene Street, Providence, on January 31, 1941, at the age of 85, having been in failing health for about two years.

During his forty-eight years as Superintendent of Health in Providence, Dr. Chapin revolutionized theories of public hygiene and made many contributions to the field of medical knowledge which gained him worldwide renown. Dr. Chapin's theory of "the person, not the thing," advanced early in his career here, combatted the then generally accepted theory that germs of disease were communicated from one person to another through the air and in various ways. He expressed the belief that disease was mostly communicated through personal contact, and that if a person who cared for another having a communicable disease were to wash his hands thoroughly after coming in contact with the patient or touching anything handled by the diseased person, he would run but little danger. When this theory was first publicly expounded by him it was greeted with derision. The experiment was watched with interest and proved entirely successful.

Some of the accomplishments in Providence during Dr. Chapin's administration were listed in a survey report by the American Public Health Association. It was pointed out that Providence was the first city in the United States to establish, in 1888, a municipal laboratory; it was in Providence that, in 1893, the first experiments in filtering water by mechanical filtration were made; Providence was the first city to discontinue, in 1905, fumigation as a form of terminal disinfection in the prophylaxis of contagious disease.

Dr. Chapin's outstanding contributions to the advancement of public hygiene were widely recognized during his long term of service as Superintendent of Health, and in retirement he was the recipient of many honors. Dr. Chapin took office when the department consisted of the head and one assistant, an ex-policeman. When he retired, he was head of a large corps of health workers and had supervised the building and development of the Providence City Hospital, the name of which was shortly changed to the Charles V. Chapin Hospital.

In 1909, Dr. Chapin, already recognized as an authority on public health work, accepted an invitation to deliver a series of lectures in the Harvard Medical School, and the treatises he there expounded were printed for wide distribution. For several years he also delivered an annual series of lectures at the Harvard-Massachusetts Institute of Technology School for Health Officers. In 1910 he published "Sources and Modes of Infection," which today is used as a textbook in medical schools. In 1913, Dr. Chapin undertook for the American Medical Association a survey of "State Sanitation" throughout the United States. His report of this survey submitted to and published by the Association, was declared a monumental work. In 1917 he was appointed one of a committee of ten eminent health experts by the National Red Cross War Council to advise on war relief and health work in Europe. In 1935 he was officially lauded by the hygiene section of the League of Nations for "revolutionizing the principles of disinfection following contagious diseases." In 1927 Yale University conferred upon Dr. Chapin the honorary degree of Doctor of Laws, and in 1928, in the presence of members of the National Academy of Sciences in Washington, he was presented the Marcellus Hartley medal for eminence in the application of science to the public welfare. Dr. Chapin was one of eight men in the world upon whom this honor has ever been conferred.

An award which was perhaps the greatest honor to be conferred on Dr. Chapin during his lifetime came to him in April, 1930, when the American Public Health Association presented him with the Sedgwick Medal, the greatest tribute within the gift of his contemporaries throughout all of North America.

In 1935, on the 59th anniversary of his graduation from Brown, the University conferred on him the Susan Colver Rosenberger Medal, the highest honor it can give an alumnus in recognition of distinguished service to humanity.

In the passing of Dr. Chapin, this country has lost one of its greatest benefactors, and Providence one of its most outstanding citizens. What he taught will live as the work of the highest type of public servant, having the welfare of his fellow men his first interest.

ARTHUR H. RUGGLES

JAMES PYLE WICKERSHAM CRAWFORD
(1882–1939)

Fellow in Class IV, Section 3, 1938

The University of Pennsylvania's distinguished Hispanic scholar Professor James Pyle Wickersham Crawford, was born in Lancaster, Pa., February 19, 1882, died September 22, 1939.

From a serious breakdown suffered in 1931 he had rallied—thanks to his invincible courage and the devoted care of his wife—to a degree that enabled him to carry on a large part of his University work. His death occurred shortly after a homeward voyage from Europe at the outbreak of the war.

After graduating from the University of Pennsylvania at twenty, he spent two years in its Graduate School, guided in his chosen field of Spanish studies by the late eminent Professor Hugo Albert Rennert. Two further years he spent in study at the Universities of Madrid, Freiburg and Grenoble. On receiving the Ph.D. degree, he started his long and honorable career at his own University.

In him were happily united the sound scholar and the dynamic teacher. He won the respect of his students for his learning and critical insight, their admiration for the joyous energy of his personality, and their gratitude for his helpfulness.

To the field of Spanish drama and poetry of the sixteenth century he contributed these outstanding books: *Life and Works of Cristóbal Suárez de Figueroa; The Spanish Pastoral Drama;* and *Spanish Drama before Lope de Vega;* all of these published by the University of Pennsylvania; the first also appeared in a Spanish translation published at Valladolid.

The list of his articles and reviews in learned periodicals here and abroad is extensive; besides which he prepared valuable school editions of various Spanish works of fiction, as well as widely-used school text-books of Spanish grammar and composition. As an editor, he was in charge of *The Modern Language Journal* from 1922 to 1926; and from 1933 to his death he was editor of the quarterly *Hispanic Review,* the publication of which by the University of Pennsylvania Press he had planned in 1930. The January 1940 number of this periodical contains a complete, classified bibliography of Professor Crawford's writings.

Besides the American Academy of Arts and Sciences, Professor Crawford was a member of the following societies: Phi Beta Kappa, the American Association of Teachers of Spanish, the Modern Language Association of America, the Linguistic Society of America, the American Philosophical Society, and the Medieval Academy of America; and a corresponding member of the Real Academia Española, the Hispanic Society of America, the Real Academia Hispano-Americana de Ciencias y Artes de Cádiz, and the Academia de Bellas Artes de Valladolid.

Franklin and Marshall College conferred upon him the honorary degree of Doctor of Letters in 1925.

George Benson Weston

WILLIAM SUDDARDS FRANKLIN
(1863–1930)

Fellow in Class I, Section 2, 1919

William Suddards Franklin was born at Geary City, Kansas, October 27, 1863, son of Thomas Henry and Cynthia Ann (Curtis) Franklin. The father was born in Philadelphia to Edward Franklin from the east shore of Maryland and Mary (Franklin) Franklin from New England; the mother was a Missouri girl. The father, a graduate of Central High School in Philadelphia, went to Kansas in 1857 to build and operate a sawmill for a Philadelphia firm. There were five children: Edward Curtis (who became professor of chemistry, Leland Stanford Jr., University, and member of the National Academy of Sciences and of this Academy), William and his twin sister Nellie, Joseph who died at 15, and Thomas Z. (with Aetna Life Insurance Co., Hartford); a high degree of ability marked them all, with William probably the ablest.

W. S. Franklin was graduated B.S. at the University of Kansas in 1887 and M.S. there in 1888. He so early showed exceptional ability in mathematics and physics that he became an instructor in physics in his second undergraduate year; following his graduation he served three years as assistant professor of physics. For the year 1890–91 he studied at the University of Berlin with Helmholz, Planck and Kundt, and during 1891–92 was Morgan Fellow at Harvard University. While professor of physics and electrical engineering at Iowa State College 1892–97, he studied further at Cornell University from which he received the degree Sc.D. in 1901. He was professor of physics and electrical engineering at Lehigh University 1897–1903 and professor of physics 1903–15; subsequently he was lecturer in physics at Columbia University (1915–17), lecturer and professor of physics at Massachusetts Institute of Technology (1917–29), lecturer at Harvard (1917–25), and visiting professor at Rollins College from 1929 till his death.

On May 14, 1888 Franklin married Hattie Fenn (daughter of Franklin Stiles) Titus of Washington, Conn. They had two sons, Curtis Titus and Vernon Lyman Kellogg Franklin. All these members of his family survived him. He died in Wilmington, N. C., on June 6, 1930, as a result of an automobile accident.

In addition to his life of teaching Franklin served engagements as consulting engineer to the General Electric Co. and other companies, and was engaged at the Bureau of Standards on war work. He had a national reputation as an electrical engineer and was an authority on alternating currents. He read constantly and widely in all branches of physics and engineering and was sympathetic to the newer theories of relativity and of quanta which came along during his maturer years. Though many thought of him as only an undergraduate teacher and writer of text books he had a considerable record of published research, great originality of mind, and his advice was always available to and highly valued by graduate students and younger scientists. The especial force of Franklin whether as productive physicist or engineer, as author of text books, or as teacher lay in his sense of reality—the world was vividly real to him and he wanted it to be so to others.

It was probably this keen sense of reality and vivid interest in persons, as well as in ideas and in things, which led him to slacken his scientific research in favor of teaching and research in teaching and further led led him to find an avocation in child welfare and in the development of outdoor recreational facilities for the young. One who had so keenly enjoyed the fishing, swimming, tramping in Western plain and mountain wished to see that so much as might should be provided for those who spent their youth in spaces less open. It was in connection with these interests that he wrote "Bill's School and Mine" and "Tramp Trips through the Rockies," and probably no scientific honor that could have come to him would have so touched him as did Bethlehem's action in naming Franklin Park in his honor.

Franklin was fellow of the American Association for the Advancement of Science (former vice-president and chairman of the section of physics), member of the American Institute of Electrical Engineers, American Physical Society, Kansas Academy of Sciences (honorary), Iowa Academy of Sciences (former president), Phi Beta Kappa, Sigma Xi, Tau Beta Pi and Phi Delta Theta. He received (posthumously) the first award by the American Association of Physics Teachers of its medal in recognition of preëminent contributions to the teaching of physics. He was elected Fellow of this Academy in 1919, member of the Council 1921–25, Chairman of the publication Committee and Editor, 1925–39. The generosity with which he gave his time to the Academy as an officer and the liveliness of his discussion of papers presented at the meetings merit especial mention here. He was always and in every capacity so thoroughly generous, alive and vivid!

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LOUIS JOHN GILLESPIE
(1886–1941)

Fellow in Class I, Section 3, 1928

Louis John Gillespie* was distinguished for the great variety of fields in which he was interested and in which he made valuable contributions, and for the breadth of vision he derived from his diverse interests. He was born at Hillsboro Bridge, New Hampshire, on June 10, 1886, the son of John Joseph and Luella (Walker) Gillespie.

In 1911 he married Elsie Vaughn Jenney. She and their two children, Louis J. Gillespie and Marguerite Gillespie Greenlie, survive him.

He received his education in the schools of Manchester, New Hampshire, and at Brown University, where he specialized in physics and chemistry as an undergraduate, and in biology as a graduate student. He received the Ph.B. degree from Brown in 1908 and the M.A. and Ph.D. degrees in 1911. During part of his graduate course he was Assistant to Professor Barus in the Physics Department.

From 1911 to 1913 he held a Fellowship in Biology in the Hospital of the Rockefeller Institute for Medical Research. In 1913 he became Bacteriologist with the New York City Board of Health, and subsequently Scientist in the Bureau of Soils of the United States Department of Agriculture in Washington. In 1915 he became Biochemist in the Bureau of Plant Industry of that Department. He was Professor of Physical

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* See the sketch by J. A. Beattie, Nucleus, *18*, 205 (1941).

Chemistry at Syracuse University during 1919 and 1920. In 1920 he came to the Massachusetts Institute of Technology as Assistant Professor of Physico-Chemical Research. He advanced to Associate Professor in 1926 and to Professor in 1931.

He was born with a keen ear, absolute pitch, facility with musical instruments and a great love for music. As a boy he learned to play the violin, piano, trumpet and trombone, and he earned most of his college expenses by the use of his musical ability. Although he never played professionally after graduation, he was actively interested in music all his life. He learned to play the cello and the viola, and for a short time he played the cello in one orchestra, the viola in another, and the trombone in a third. He composed a score of short piano pieces, two string quartets and a symphony. He was also greatly interested in the physics of music, especially as it related to the tone color and quality of musical instruments, and to those musical intervals which give esthetic satisfaction.

His first publications, from Brown University, dealt with the application of precise physico-chemical measurements to biological problems. At the Rockefeller Institute he shared in the pioneer work of characterizing the different types of pneumococci. At the Department of Agriculture he returned to the application of physico-chemical technique and reasoning to biology in the development of methods for measuring hydrogen-ion potentials and reducing potentials, particularly in soils. He pioneered in educating the biological and agricultural chemists to distinguish between these two potentials, and between them and the quantities of acid and reducing agents.

At the Massachusetts Institute of Technology his biological interests were continued in a course in physical chemistry for students of biology and in the text book "Physical Chemistry," which he wrote for it. He also developed a graduate course in thermodynamics, which was largely an exposition of Gibbs' original papers. His research was mostly in thermodynamics, including studies of calorimetry, solid-gas equilibria, and the effect of pressure on chemical equilibria in non-ideal gases. His research, like his music, was strongly individualistic. Neither the problem chosen nor the methods of attack followed the fashion, but both reflected the breadth of his vision. His studies of thermal diffusion were very timely on account of the widespread interest in the separation of isotopes by this method. Yet his own chief interest was in solving the difficulties which he had brought to light before the subject became popular, his approach was unusual, and his publication was unhurried. His researches are published in more than fifty scientific articles.

Important as were the direct results of these varied activities, the effect on his own development was perhaps fully as important. He was a teacher and a guide whose broad knowledge, wide perspective and keen judgment were always at the service of his students and colleagues. He contributed much by doing, even more by being.

George Scatchard

WILLIAM ARTHUR HEIDEL

(1868–1941)

Fellow in Class IV, Section 1, 1910

William Arthur Heidel was born in Burlington, Iowa, in 1868, and died in Middletown, Connecticut on January 15, 1941, in his seventy-third year. A graduate of Central Wesleyan College he proceeded for graduate instruction in the classics to the university of Berlin. Here he was fortunate enough to receive the personal instruction and friendship of Professors Zeller and Diels who inspired him to undertake for his life work the study of ancient Greek philosophy. After a two-year sojourn abroad, he returned to this country to complete his work for the doctorate at the University of Chicago, then still a very young university, under the guidance of Professor Shorey. It was here also that his long friendship with Professor John Dewey began. One of the earliest philosophical books, in part written and wholly edited, by John Dewey, *Studies in Logical Theory*, contains an article by Professor Heidel on The Logic of the Pre-Socratic Philosophy. While it was difficult for Professor Heidel to choose between a promising career in philosophy or in the classics—Professors Shorey and Dewey simultaneously offered him teaching posts at Chicago—he finally determined to devote himself to classical studies, but with particular reference to pre-Socratic philosophy and science. It was in this field that he was to win singular distinction at home and abroad.

His first teaching appointments were in the Middle West; but from 1905 on he became professor of Greek at Wesleyan University in Middletown, Connecticut, where he continued to teach until 1928, when he was appointed a Research Associate of the American Council of Learned Societies to carry on his work on the History of Greek Thought. In 1938 he became Research Associate Emeritus.

Professor Heidel's carefulness in scholarship and his hostility to dogmatism kept him from hasty publication; but steadily important studies emerged from his pen that had been sometimes twenty years in the maturing. Some of the more important of these studies like his Περὶ φύσεως, *A Study of the Conception of Nature Among the Pre-Socratics* and his *Hecataeus and the Egyptian Priests in the Herodotus, Book II*, as well as many other smaller studies appeared either in the Proceedings or the Memoirs of the American Academy of Arts and Sciences. His scholarship was as carefully etched as was his miniature handwriting his friends came to know.

While he always stressed how meager was the evidence for much we should like to know in early Greek thought, his enthusiasm for new clues and new modes of approach always carried him forward. In later years it was the scientific theory and practice of the ancient Greeks, particularly of the followers of Hippocrates, that engrossed his attention. It is to be hoped that some of the important material he was working on when death overtook him can be published posthumously.

With all of Professor Heidel's great learning he was not a recluse: the life of the nation and of the world concerned him greatly. The range and accuracy of his knowledge on many subjects unrelated to the academic life never failed to surprise his friends. In late years his keen sense of justice and his great capacity for sympathy were often strained when he would hear, sometimes directly, of another great injustice done to a distinguished scholar abroad. While Professor Heidel's scholarly work was set in ancient Greece, truly his eyes surveyed the world.

Cornelius Krusé

WILLIAM CASPAR GRAUSTEIN
(1888–1941)

Fellow in Class I, Section 1, 1924

William Caspar Graustein was born in Cambridge, Mass., November 15, 1888. He graduated from Harvard, Magna cum laude, in 1910. He spent the next year in the same place doing graduate work in mathematics; his main interest then, as ever afterwards, was in the field of geometry. For this reason it was entirely natural that he should spend the next two years in Bonn working with that distinguished, but highly individualistic geometer, Eduard Study. This was the beginning of an intimate personal and intellectual intimacy which lasted many years, and had a most profound effect on Graustein's whole scientific career.

He took the doctor's degree, Summa cum laude, in Bonn in 1913 and returned to Harvard for a year as instructor in mathematics. He was then promoted to an assistant professorship in the newly formed Rice Institute in Houston, Texas. Here hs joined his Cambridge friend, Griffith Conrad Evans in building up, with the warm approval of President Edgar Odell Lovett, the most advanced mathematical centre south of Mason and Dixon's line. This lasted until the war.

He returned to Harvard in the autumn of 1919 to help in the congenial task of rehabilitating the Division of Mathematics, which in one year had lost three of its most valuable members through death and transfer. He worked mightily at this task till the day of his death, climbing steadily to the top of the academic ladder. He was chairman of the Division from 1932 to 1937, and Assistant Dean of the Faculty of Arts and Sciences from 1939 to 1941. But he served mathematics outside his own university as well. He was for many years one of the leading editors of the Transactions of the American Mathematical Society, and chairman of a very busy committee organizing a proposed International Mathematical Congress to be held in Cambridge in 1940. He was killed in a motor accident January 22, 1941.

Graustein's approach to mathematics was essentially the artistic one. He was never attracted to a new theory merely because it was novel or bizarre. Neither did he take pleasure in extended mathematical elaborations the only apparent object of which is to show the writer's virtuosity. His object was to reach some definite mathematical truth by the most attractive road, and to state it as generally and as accurately as possible. His doctoral thesis dealt with a method of representing all points, real or complex, of a space curve, by two real surfaces of special type in a definite relation to one another. In subsequent years he published other papers on complex geometry, but the method of representation suggested to him more general problems connected with mapping of one surface on another especially when the tangent planes at corresponding points are parallel. The introduction of the absolute differential geometry, and tensor notation had a curious effect on him. He clearly saw the great increase in generality that came in this way, and he mastered the new technique. But he also was led to perceive resources in the older geometry that had been somewhat neglected before. In particular he stressed the advantages of so called invariant methods which are independent of the more or less fortuitous choice of parameter systems for determining elements. His paper, "Méthodes invariantes dans la géométrie infinitésimale des surfaces," was awarded a prize by the Belgian Academy of Sciences in 1929; an elaboration in English was delivered, by request, before the American Mathematical Society a year later and was published in their Bulletin in August 1930. The totality of his scientific papers, mostly in the field of differential geometry, amounts to some three dozen titles.

The quality which makes Graustein's papers excellent reading was manifest in his teaching, for he was a most admirable teacher, clear, painstaking and stimulating. He published three timely geometrical text-books, "Plane and Solid Analytic Geometry," with W. F. Osgood, 1921; "Introduction to Higher Geometry," 1930; "Differential Geometry," 1935. But no printed page could convey the real quality of the teacher or the man.

JULIAN L. COOLIDGE

SAMUEL HENSHAW (1852–1941)

Fellow in Class II, Section 3, 1889

Samuel Henshaw was born in Boston, January 29, 1852, and died in Cambridge, February 5, 1941. Of an old Boston family he was the son of Joseph Lyman Henshaw and Jane Paine Henshaw. He had a sister, Elizabeth Lyman Henshaw, who died October 24, 1926, and a brother, Joseph Putnam Bradlee Henshaw, who died October 11, 1930. Samuel Henshaw married Miss Annie Stanwood, April 28, 1886. She died March 12, 1900. Her death was a desperate blow that radically changed all his subsequent life.

Henshaw went to the Chauncy Hall School, and the Boston Latin School. He did not go to college, but received an Honorary A.M. from Harvard in 1903.

Henshaw was short in stature; but very strong. He had wonderful eyesight so that he could read the finest print and he never wore glasses, even in his old age. He had a very keen and critical mind in affairs and in his relations with men. This gave his judgment great weight with his associates. The keynotes of his character were his sensitiveness, his sense of fun, his personal integrity and his devotion to his work and his friends.

Primarily an entomologist, he had wide knowledge in other groups of animals, and his knowledge of scientific literature was both very great and very accurate. This helped him greatly in his editorial work which was very extensive throughout his active years. He was gifted with a singleness of purpose and an intense application to work that is rarely equalled.

All his life interested in natural history, he became a member of the Boston Society of Natural History in 1871. In 1876, I first find record of his working on the collection of insects in the Society. From that time on, until 1891, Henshaw was working at the Boston Society as assistant to Professor Alpheus Hyatt. While insects were his primary interest, he worked on various groups of invertebrates and vertebrates as well, and assisted Professor Hyatt greatly in preparing material for his courses in the Teacher's School of Science, a department of the Lowell Institute.

In 1892, Henshaw became Secretary and Librarian of the Boston Society of Natural History, which position he held until 1901, when he was succeeded by C. F. Batchelder, and a year later by Glover M. Allen.

In 1891–1898, Henshaw was part-time assistant in entomology at the Museum of Comparative Zoölogy, succeeding Dr. H. A. Hagen, who had retired on account of illness. From 1898–1903, he was assistant in entomology and librarian of the Museum of Comparative Zoölogy. From 1903–1911, he was Curator of that Museum, when his title was changed to Director, and this position he held until November, 1927, when he was succeeded by Dr. Thomas Barbour. From 1927, his title has been Director of the University Museums and of the Museum of Comparative Zoölogy, Emeritus.

Henshaw was a Fellow of the American Academy of Arts and Sciences, member of the American Society of Naturalists, and American Society of Zoölogists. He was one of the founders of the Cambridge Entomological Club, which started publishing Psyche in 1874, and for a time he edited that Journal,

While Secretary of the Boston Society of Natural History, he edited their publications and during at least a large part of his connection with the Museum of Comparative Zoölogy, he edited the publications of that institution. As an editor, he was most painstaking, careful and exact.

When I first knew Henshaw, he lived in Mercer Circle, Cambridge, and later I became his opposite neighbor in Fayerweather Street. He was essentially a gentleman of the old school, with all the refinement and courtesy that that term implies. This in spite of a "crust" that often hid his finer feelings. These finer feelings were expressed in his devotion to his close friends, especially Dr. H. A. Hagen, Mr. Samuel H. Scudder, and Dr. Henry P. Walcott, notably in the years of their invalidism. Among others to whom he gave his great loyalty and devoted interest were Professor Alphaeus Hyatt, Dr. George L. Goodale, Walter Faxon, and Mr. Alexander Agassiz. He frequently visited Dr. Goodale and after the latter's death he sent to his widow lilies of the valley every Christmas as long as she lived. His sympathy went out especially to children, whom he dearly loved and he entered into their joys with a spirit of comradeship that won their deep love and admiration. He planned with children trips to the circus, or a sleigh ride, or to the theatre, when he was the life of the party. He was very fond of animals as pets, especially dogs, and anyone who would abuse a dog roused his wrath. Personally very generous, he hated all meanness, sham, or hypocrisy with a violent detestation.

During his later years, when crippled by arthritis and much of a recluse, his close friends, Dr. Alfred M. Tozzer of the Peabody Museum, and Miss Gertrude A. Thurston, his former secretary at the Museum, gave him most devoted care.

Henshaw did not publish extensively and his principal publications were on insects. Dr. P. J. Darlington, Jr. of the Museum of Comparative Zoölogy kindly gave me a very complete list of his publications: 1885, List of the Coleoptera of America North of Mexico, Am. Entomological Soc., 161 pp., of which he published supplements in 1887, 1889 and 1895. He also published, 1889–1896, Bibliography of the more important contributions to American economic entomology in five parts, over 700 pages, Washington, U. S. Dept. of Agriculture, Division of Entomology, and in 1898, The entomological writings of George Henry Horn, Trans. Am. Entomological Soc., vol. 25 pp., XXV–LXXII. Besides these, he published some thirty other papers, mainly on insects, also obituary notices of his close friends, Dr. H. A. Hagen, Prof. Alpheus Hyatt, Roland Hayward and Walter Faxon, and as well his annual reports in the Museum of Comparative Zoölogy.

Besides his natural history work, Henshaw was essentially a bibliophile and did an immense amount in building up to completeness the libraries with which he was connected. In addition, he had been acquiring for long years a very extensive collection of Gilbert White's Natural History of Selborne. Many years ago he told me that he had over 100 editions of that work. Mr. Thomas Franklin Currier of the Widener Library at Harvard writes me: "I feel certain that nowhere else is there gathered together so complete and comprehensive a collection of materials relating to the author of the Natural History of Selborne, embracing not only books and pamphlets, but manuscripts, prints, photographs . . . and Henshaw did not stop with mere collecting; he knew the inside of his books . . . A fairly complete scientific bibliography of White could probably be made without going out of the Henshaw collection." This great White collection, with his other books and manuscripts, Henshaw in his will left to the Bodleian Library at Oxford, with the feeling that as an English work it most properly belonged there.

ROBERT T. JACKSON

FREDERICK LAWTON
(1852–1941)

Fellow in Class III, Section 1, 1921

Frederick Lawton, lawyer and judge, was born at Lowell, May 10, 1852, the son of James and Sarah (Priest) Lawton. He received his early education in the public schools of Lowell and graduated with the degree of A.B. from Harvard University in the class of 1874. Then followed a period of teaching, first at Chicopee, Mass. and later for three years as principal of the Brookline High School. He studied law in Lowell in the office of Charles F. Howe, Esq. and was admitted to the bar of Massachusetts in 1880. He then engaged in general practice in Lowell in association with his brother George F. Lawton, who was later for many years Judge of Probate for Middlesex County.

In the same year in which he began the practice of his profession Frederick Lawton married Helen Mack of Lowell, the daughter of a well-known business man and former mayor of that city. There are two sons of this marriage, Richard M. Lawton and John S. Lawton. The marriage was a preëminently happy one. Mrs. Lawton was a woman of high intellectual attainments. The Lawton home, first in Lowell, and later in Boston, to which city the family moved in 1908, became and continued for nearly forty years to be a center of attraction for many persons of culture and learning. Mr. Lawton in close collaboration with his wife developed wide interests in many fields of reading and study far remote from the confines of his profession. These were pursued continuously and systematically and were supplemented by frequent trips to Europe for which careful preparation was made by the study of the history and language of the countries to be visited.

Mr. Lawton's activities included three years in the State Senate as the representative of his Lowell district, beginning in 1893. He was a trustee of the Lowell Textile School and of Rogers Hall School in Lowell. He was interested in the Mechanics Association there. He was a member of the Harvard Club, of the Union Club, and of the St. Botolph Club in Boston.

In 1900 Governor Crane appointed him an Associate Justice of the Superior Court of Massachusetts. Upon his twenty-six years of service to the State in this high office rests his principal claim to public remembrance and gratitude. To the essential virtues of impartiality and unquestionable integrity Judge Lawton added the equally important virtue of unfailing devotion to duty. He was dignified in manner, rapid in the dispatch of business, quick and decisive in his rulings, and diligent and prompt in disposing of reserved cases. His charges to juries were clearly expressed and carefully adapted to the requirements of each case. Although he performed continuously for many years the arduous labor of hearing litigated cases he never fell a victim to the mental weariness and flagging of interest which after a time has lessened the usefulness of many capable judges. The strong sense of humor which made him an exquisite raconteur among his guests at home came to his aid on the bench and kept keen and active his interest in the human drama which was constantly unfolded in his court room. The beginning of each new day found him fresh and eager for whatever task it might bring. Another helpful characteristic was his liberal attitude of tolerance of the opinions of others which made him ready to listen to all arguments, even though he might be inclined to disagree with them, and to consider cases from all possible points of view.

It would be impossible to do more than to summarize in general terms Judge Lawton's work upon the great trial court of his native state. That court was one of general jurisdiction of actions at law, suits in equity and criminal prosecutions. Its work was growing rapidly during the period of his service upon it. When he took office there were eighteen justices. When he retired the number had increased to thirty-two. He carried at all times his full share of the burden. He sat as occasion required in all parts of the Commonwealth. He was everywhere a favorite with the clerks and officers who served under him in his sessions. He was universally respected and trusted by the bar. He tried cases of all kinds from those involving ordinary commercial transactions and money interests to those involving divorce, contested wills, and murder. He tried both jury cases and cases without juries in which he determined both the facts and the law. The number of cases he heard would be counted in the thousands. His reputation grew steadily with the advance of years and accumulation of experience.

The death of Mrs. Lawton in 1919 was a great blow to Judge Lawton. Nevertheless he continued his work with unabated zeal, and his friends continued to find a cordial welcome and good company at his Boston apartment. Not only did his children keep in close touch with him at all times, but in addition a peculiarly intimate and comprehending relationship grew up between the judge and his grandchildren and their young friends who frequently visited him.

In 1926, at the age of seventy-four, he retired from the court while still in apparent good health. In 1930 he was again called to public service to succeed Judge Fessenden as the representative of the Superior Court on the Judicial Council, a permanent board established by law for the investigation of the judicial system and the recommendation of improvements in the administration of justice. For five years he regularly attended the meetings of the Council. Although it might, perhaps, have been expected that Judge Lawton would incline somewhat towards the conservative side on questions of change, it is said on good authority that he took a generally progressive position and that he was ready to throw his weight on the side of change whenever it seemed likely that good could be accomplished.

At length advancing years took their inevitable toll in declining strength. After a long illness Judge Lawton died at his Boston apartment on March 30, 1941. If he had lived a few weeks longer he would have been eighty-nine years of age. He will be remembered and honored chiefly for his long, faithful, and able service as a justice of the Superior Court, but by the survivors of those who were fortunate enough to be admitted to the inner circle of his home he will be remembered more intimately as a gracious host and a charming gentleman.

STANLEY E. QUA

HERBERT VINCENT NEAL
(1869–1940)

Fellow in Class II, Section 3, 1914

Herbert Vincent Neal, biologist and teacher, was born at Lewiston, Maine, on April 3, 1869. On February 21, 1940, he met accidental death on a Texas highway while driving from Mexico City to California. He is survived by his wife, Helen Phillips Howell of Southold, New York, to whom he was married on June 8, 1899, and by three children, Margaret and Helen (twins, born February 26, 1901) and John Howell (born July 13, 1906).

He received his bachelor's degree (A.B.) at Bates College in 1890 and during the next two years served as instructor in history and Latin at St. Paul's School, Garden City, New York. In 1892 he entered Harvard University as a graduate student in biology. His chief work was done in association with Professor Edward L. Mark. It resulted in a doctorate thesis (1896) entitled "The Segmentation of the Nervous System in Squalus acanthias: a Contribution to the Morphology of the Vertebrate Head," published in the Bulletin of the Museum of Comparative Zoology at Harvard College, volume 31, 1898. From Harvard University he received the following degrees: Bachelor of Arts in 1893, Master of Arts in 1894 and Doctor of Philosophy (in Zoology) in 1896.

After his four years at Harvard he spent a year (1896–97) in Europe continuing work on his doctorate problem, mainly at Munich in the laboratory of C. von Kupffer, an authority on the development of the head of vertebrates.

At the end of his year abroad, Neal returned to become Professor of Biology at Knox College, Galesburg, Illinois. Occupying this position for sixteen years, he became known as an unusually effective teacher and as a competent and constructive biologist. In 1913 he succeeded the late John Sterling Kingsley at Tufts College and served there as Professor of Zoology until his retirement in June, 1939. From 1924 to 1935 he also acted as Dean of the Graduate School.

He was Curator of the Barnum Museum of Tufts College. In 1931 the honorary degree of Doctor of Science was conferred upon him by Bates College.

Dr. Neal was actively associated with biological laboratories on the coast of Maine. He became assistant Director of the Harpswell Laboratory in 1908 and served as Director from 1913 to 1917. He became a trustee of the Mount Desert Island Biological Laboratory in 1921 and was Director from 1926 to 1932. His enthusiastic interest gained for these institutions much material assistance and helpful support. Also he was a member of the Corporation of the Marine Biological Laboratory at Woods Hole and of the Corporation of the Bermuda Biological Station for Research. He was a trustee of Bradford Junior College and of Bates College.

Neal's early scholarship is attested by his membership in Phi Beta Kappa and Sigma Xi. Later he acquired membership in the following societies: American Association for the Advancement of Science (Secretary of Section F, 1913–20), American Academy of Arts and Sciences, American Society of Naturalists, American Society of Zoologists (Secretary-Treasurer of Central Branch 1910–11; President of Society, 1930), Association of American Anatomists, Boston Society of Natural History, The Illinois Academy, The Russian National Academy of Science (Corresponding Member). As a Fellow of The American Academy of Arts and Sciences, he rendered important service for four and a half years (1929–34) as Editor and Chairman of the Committee of Publication of the Academy.

Some men are born teachers; others have teaching thrust upon them. It was Neal's genetic good fortune to possess those inherent peculiarities, intellectual and emotional, which enable one human mind to reflect truth into others. The brightness and clarity of his mind, its ability to discriminate between the vitally relevant and the unimportant, its keen appreciation of all that is implied by the complexity, inter-relation, continuity and progressive development in the living world made this reflection far more than a literal delineation of tangled reality. His mind focused deeply into that reality and projected a picture of an organic world whose overwhelming diversity and complexity were even exceeded by its evidences of order, harmonious adaptation, integration of smaller into greater living units, and something which has at least the external appearance of a persisting purpose. In all of his teaching the deductions from biology were brought to focus on the problems of the origin, nature and destiny of the human organism. His better students derived from lasting inspiration. Those who were incapable of seeing all that he put before them at least knew that there was something there and they admired and respected him. Although often heavily burdened with teaching responsibilities, he always gave to his students ungrudgingly of his time and energies. He could have done many other things but he always put the teaching first because he loved the doing of it and because he was deeply interested in the human beings who were his students. Many of them are now engaged in medical or other scientific work.

Neal's contribution to the science of biology is not to be measured by the number of titles of his published work. The list is not long. Its titles indicate his persisting interest in the subject which first attracted him—the perplexing problems presented by the segmental structure and arrangement of nervous and other organs in the head of vertebrates. His earlier papers constitute a substantial addition to our knowledge of the embryological facts and offer much toward the interpretation of them. Later papers deal with the embryonic origin of nervous elements. But it was in the direct impact of his forceful personality and invigorating teaching upon a continuous procession of students over a period of nearly a half century that he did his most important service to science.

Much of his time in the last few years of his life was given to the writing of books designed to serve as texts of somewhat advanced nature—a "Comparative Anatomy" (of vertebrates; 1936) and a "Chordate Anatomy" (1939), both with some collaboration from H. W. Rand of Harvard University. At the time of his death he had in nearly completely form the manuscript for a book which was intended to express his views concerning the biological origin and nature of man and which, it is to be hoped, will tell us much more than is widely known of the author's fine philosophy of life. It is much to be desired that this manuscript should find early publication.

Neal's dominating concern with problems of human biology made it inevitable that his zoological interest should have centered on the vertebrate animals. It was highly appropriate, therefore, that in his position at Tufts College he should have succeeded John Sterling Kingsley, eminent for his work in the field of vertebrate comparative anatomy. To Kingsley's extensive knowledge and constructive research in anatomy, Neal added interpretation and philosophical insight.

From his student days onward it was evident that the detailed facts of biological structure and function were of interest to Neal chiefly as data which might yield some satisfaction to the common craving for an "explanation" or "interpretation" of "life" or might give us an answer to our query as to the "meaning" of life—if, indeed, it has any meaning. In 1934 he published a small book (87 pages) entitled "Vitalism and Mechanism—a Discussion." It consisted merely of letters exchanged, over a period of many years, between him and James F. Porter, a friend from graduate-student days. Porter, a business man of sensitive and artistic temperament and scientific interests, argues for mechanism. Neal's letters express vigorously his dissatisfaction with mechanism and his conviction that "by no hocus-pocus can mind be conjured out of matter."

Neal's philosophy is best judged by a philosopher. Tufts College, on April 21, 1940, held a memorial service for him. At this service his friend, William Ernest Hocking, referred to him as "a colleague in the teaching of philosophy" and spoke at some length concerning Neal's philosophy of biology. The following is quoted from Hocking's address. Speaking of the element of wonder as an accompaniment of scientific outlook—". . . Herbert Neal was a man to whom this element of wonder became an imperative. He saw that in the ideal of self-forgetfulness, which is part of the greatness of the scientific spirit, there lurked a danger that the scientist might *forget himself* as a part of that phenomenon which is to be understood. Consciousness, the capacity for pleasure and pain, the power of making judgments of good and evil, of right and wrong,—this extraordinary power of setting up an ideal of truth for truth's sake which is the very heart of the scientific code,—these powers are also products of the living universe. Evolution has produced marvelous organisms; but it has produced also something more marvelous,—organisms which are *aware of* marvelous organisms, and which can consider the whole complex history, debouching in themselves, and speculate about it. That Nature has produced the human body is a marvel; that it has produced the Thinker is more marvelous still."

"It was the peculiar insight of Herbert Neal that he could not forget, nor allow his students to forget, this double nature of the problem of evolution. Could Nature have produced the body without producing the mind? Could Nature have evolved the human body without evolving the human mind?" Never accepting naïve mechanism and finding a vitalism which invokes non-mechanical or "vitalistic" agencies equally inadequate, he believed that ". . . the answer had to be sought, not in any detail of the process, as if mind—hitherto absent from the universe—had one day *emerged*, as an incalculable new quality,—but in the character of the universe as a whole, which *never was* devoid of mentality and meaning. It is not for nothing that livingness is felt to be present in the whole." For Neal ". . . the presence of a living character in Nature as a whole was . . . *the reality*, the deepest reality with which we have to do . . .".

In addition to his philosophy of biology and life, but in every way consistent with it, Neal held a philosophy of human *living*. Of the former he was ever ready to talk and did so with characteristic eloquence and earnestness. Of the latter he rarely spoke; yet it was far better known to his associates than was the former because his daily living gave to it more vivid expression than could any words. He lived as one who had been privileged to spend a limited time in some enchanting country. No landscape, no adventure which that land afforded was to be missed. He therefore lived actively, intensely. His nearest approach to idleness was time spent in contemplation of the world's beauty. But it was not a foreign land in which he sojourned. He felt himself to be a part of a living universe. He therefore found the world altogether friendly. He saw in it meanness and evil and he hated them, but he hated no human being. He had only compassion for the man in whom evil resided.

The breadth of his capacity for appreciation was extraordinary. The music of Bach he enjoyed, not as a duty but from the heart and he took pleasure in modern light music—of the better sort. His appreciation of Shakespeare was equalled by his delight in a Charlie Chaplin comedy. But the morbid sordid realism which some recent plays affect aroused his complete disgust. Emerging from a theater late one evening after seeing such a play, he said to the friend with him, "Now let us take a long walk in the cold clean air and under the starlight and get that out of our systems." He was to a surprising degree familiar with music, literature, painters and paintings. He was more than merely passively artistic. His water colors and his playing of the violin revealed capacities which might have been developed far if he had not chosen science. He traveled much, always with camera in hand. His collection of lantern slides, colored by himself, was the envy of professional photographers. The wonder is that he was able to do such a diversity of things and to do them all well.

Neal was loyal to his responsibilities as a citizen. He was always actively interested in social, civic and political affairs. He was not so academic that he could not serve a three-year term (1906–09) as alderman from the Sixth Ward of Galesburg, Illinois. In June, 1918, he volunteered for service under the Young Men's Christian Association in its work with the Italian army in the "World War." He was sent to Italy in August, 1918, and served there until August, 1919. From January to July, 1919, he was stationed at Genoa, acting as Regional Director. He held the rank of Captain in the Italian army.

Neal's joy in living radiated from him. All who knew him marveled at his spirit of eternal youthfulness. The gracious and generous hospitality of his home will always be remembered by his students and friends. If all men could live by Neal's philosophy, world wars would be replaced by world tolerance and world friendliness. Science and the arts would flourish. And each day of human living would mark some progress in the coöperative striving toward the realization of all that is finest and noblest in the potentialities of the human organism.

Herbert W. Rand

ALFRED BARTON RENDLE
(1865–1938)

Foreign Honorary Member in Class II, Section 2

Alfred Barton Rendle was born in London, January 19, 1865, the eldest child and only son of John Samuel and Jane Wilson Rendle. He was educated at London schools and at St. John's College, Cambridge. There he came under the stimulating instruction of S. H. Vines. Probably he would have liked nothing better than to remain as a member of the school of research which Vines was then endeavoring to build up; but the latter's removal to Oxford put an end to any such hope. Rendle, in need of a position, applied for and got one as Assistant in Botany at the British Museum, left vacant by Ridley's transfer to Singapore.

Although the change from physiological investigation under Vines to the career of a taxonomist and museum official came about fortuitously, it was not made without conviction. Rendle had always been interested in classification and he proved a capable systematist in the British tradition. He steadily advanced in the Museum, becoming Keeper of Botany in 1906 and holding that post until his retirement in 1930.

He found time and energy for various activities outside his immediate duties. He served the Linnean Society as member of the Council, Botanical Secretary (1916–23), and President (1923–27). He took an active part in the work of the Royal Horticultural Society and was awarded two of its medals. For twelve years he was evening lecturer on botany at the Birkbeck Institute. He did much for the conservation of the native British flora. He took a lively interest in bibliography, no doubt fostered by long association with James Britten. I well remember the warmth with which he received a minor discovery of mine in that field:—as I remember the almost fatherly hospitality with which he saw to it that I, a first-time visitor to the Museum, should miss nothing to my pleasure or advantage.

No taxonomist of Rendle's time could escape questions and controversies in nomenclature; though said to have had no great liking for the subject, he was very much concerned with it. He aided in drawing up the original International Rules of 1905, served on the editorial committee of successive congresses and became its head after Briquet's death. Following the Congress of 1905 he prepared, in collaboration with Britten, a list of British seed-plants and ferns in order to test the workings of the then new rules. Britten, a bibliographer rather than a practical taxonomist, inclined to the radical and uncompromising in matters of nomenclature; the list applied certain provisions of the rules not wisely, but too well. However, for that very reason it went far to bring about the formulation and prompt incorporation into the rules of the useful principle of illegitimate names.

An administrative officer of a museum must often sacrifice his own productivity to the duty of keeping its collections in condition for the use of others. The bulk of Rendle's published work is not great, and its direction was often determined by the immediate needs of the Museum. One major enterprise, the Flora of Jamaica, begun in 1910 in collaboration with William Fawcett, he initiated and carried well toward completion, five of its seven projected volumes have been published when he died. The work is in the tradition of the great series of British colonial floras; Rendle's future reputation will rest mainly upon it.

His one other large work—two volumes on the classification of flowering plants—sprang from his teaching. He believed in the educational usefulness of taxonomic botany—it required, he wrote, a minimum of apparatus and forced the student to systematize observed facts. Also, like many working taxonomists, he distrusted phylogenetic conjecture, none the less when it was his own. He maintained that "certainty of identification" was "more important than guesses at affinity, particularly by those with little knowledge of generic and specific differences."* Accordingly, his text-book is deliberately conservative, following the Eichlerian system closely, and makes little attempt at originality. Possibly for that reason, it holds a place among the standard works of its kind.

Rendle was a regular attendant at scientific conventions, often in distant countries. He was taken ill while on his way to one of these, a meeting of the British Association in India late in 1937, and was brought home to die, January 11, 1938.

C. A. Weatherby

CHARLES WARDELL STILES
(1867–1941)

Fellow in Class II, Section 4, 1921

Dr. Charles Wardell Stiles, for many years in the U. S. Public Health Service, Washington, D. C., in which he became Medical Director prior to his retirement from active duty on October 1, 1931, died of myocarditis at the U. S. Marine Hospital, Baltimore, on January 24, 1941.

He was born in Spring Valley, N. Y., on May 15, 1867, and received his early education at Wesleyan University, Middletown, Connecticut, later studying at the Collège de France, the University of Berlin, the University of Leipzig, the Pasteur Institute, and the Trieste Zoölogical Station. He received his Ph.D. degree at the University of Leipzig in 1890, under the famous parasitologist, Leuckart, and was awarded a number of degrees in this country, including an honorary M.D. from the University College of Virginia, in 1913.

Dr. Stiles' professional career began in 1891, when he was placed in charge of the Zoölogical Laboratory of the Bureau of Animal Industry, U. S. Department of Agriculture. In 1902 he joined the U. S. Public Health Service, as zoölogist, becoming in turn professor of zoölogy, assistant surgeon, and finally medical director. From 1892 he gave lectures on medical zoölogy and held teaching positions in Georgetown University, the Army Medical School, Johns Hopkins University, and the Naval Medical School. Since 1931 he had been an associate of the Smithsonian Institution, and professor of zoölogy at the Rollins College, winter faculty, in Florida. He was a member of numerous American and foreign scientific and medical societies. In 1892 he was elected foreign correspondent, of the Société de Biologie, France; in 1896 foreign correspondent of the Académie de Médicine, France; and in 1899 corresponding member of the Zoölogical Society of London.

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* Ramsbottom in Proc. Linn. Soc. London 150: pt. 4, p. 329.

In addition Dr. Stiles was active in his fields as scientific secretary of the Rockefeller Commission for the eradication of hookworm, honorary custodian of the helminthological collections in the U. S. National Museum, secretary to the advisory commission of the Smithsonian Table at Naples Zoölogical Station, secretary of the International Commission on Medical Zoölogy, and secretary of the International Commission on Zoölogical Nomenclature. He served also, from 1895–1930, as U. S. delegate to international zoölogical congresses in Leiden, Cambridge, Berlin, Berne, Boston, Gratz, Monaco, Budapest, and Padua. His mental capacity for weighing the quasi-legal questions involved in taxonomic tangles, and his sound judgment in the formulation of international rules to govern nomenclatorial procedure made him invaluable in this field.

During 1898–1899 he was detailed by the Secretary of Agriculture as agricultural and scientific attaché to the U. S. Embassy at Berlin, and his report published in 1901, particularly the part relating to his investigations on trichinosis, furnished convincing and important data.

The subjects of his many publications relate chiefly to parasitology and to human and veterinary medicine, and include studies on parasitic protozoa, hookworm and rural sanitation, trematodes, cestodes, anthelmintics, surra, verminous diseases of cattle, classification of ticks, zoölogical classification, and many others. Perhaps he is best known for his recognition of hookworm disease as an important health problem in certain regions of the Southern States and for the demonstration here of a species distinct from the old-world hookworm. Other outstanding accomplishments of Dr. Stiles are the preparation of the Index-Catalogue of Medical and Veterinary Zoölogy (in collaboration with Dr. Albert Hassall), his Monographs, Bulletins, and the Key-Catalogue of the Parasites of Man and Animals, indexed in all the more important languages, and utilized the world over by parasitologists.

The thoroughness, accuracy, and high standard of Dr. Stiles' scientific investigations, his ability to analyze and evaluate data, to clearly and impartially present the facts, and his skill in deducing accurate conclusions, serve as an inspiration and guide to other workers in the field of parasitology.

E. E. Tyzzer

HENRY TABER (1860–1936)

Fellow in Class I, Section 1, 1891

Henry Taber was born at Staten Island, N. Y. on June 10, 1860 and died at Worcester, Mass. January 6, 1936; he is buried beside his wife in Princeton, Mass., on one of the high plateaus of Mount Wachusett. He was the eldest son of Charles Corey Taber, a cotton dealer and broker of New York city, and his wife Cornelia Frances Martin, of Flushing, L. I., and was a descendant of Philip Taber who came from Essex, England to Plymouth, Mass. in 1630.

Henry Taber entered Yale with the class of 1881; leaving college for a time on account of illness, however, he became a member of the class of 1882 in the second half of the junior year. He had been pursuing a course in mechanical engineering, but feeling that he was unfitted for this career he was permitted to substitute a special course in mathematics for part of the work. His membership in Berzelius and other Yale clubs was a source of great pleasure to him as he returned to reunions in later years.

The next three years were spent in graduate mathematical study under the great Sylvester, at the Johns Hopkins University where he was awarded the Ph.D. degree in 1888. After a year as an assistant he became a docent in mathematics at Clark University, then, as assistant professor (1892–1903) and professor (1903–21) he was an associate of Professor W. E. Story and very active in mathematical research. He retired as professor of mathematics emeritus in 1921.

Clark University was organized for strictly post-graduate study, and did not aspire to compete with other institutions in the work that is generally recognized as undergraduate. Thus a very distinguished group of scholars was assembled on its Faculty. But with the founding of the University of Chicago and a changed attitude of the founder of Clark, a staggering blow was dealt to the institution when many of its faculty, including the fine mathematician Oskar Bolza, decided to go to Chicago. Of the 24 candidates for the Ph.D. in mathematics, presented at Clark by Professors Story and Taber during 1892–1917, five had worked under the direction of Doctor Taber, namely: E. R. Rettger, S. E. Slocum, R. B. Allen, J. A. Bullard, and S. Zeldin.

His chief mathematical interests were in the fields of matrices and bilinear forms, continuous groups, and hyper-complex numbers. More than thirty of his papers and memoirs were published in *Amer. Jl. Math.* (1890–1916); Amer. Acad. A. Sci., *Proc.* (1891–1913); Amer. Math. So. (a) *Bull.* (1894–97), (b) *Trans.* (1904); Int. Congress Mathems., Chicago, *Mathematical Papers* (1896); *Mathem. Annalen* (1895–1917); *Math. Reviews*, Story (1897); Paris, *Comptes Rendus* (1906).[1] Already in 1893 he was one of only eleven American mathematicians presenting papers at the International Congress of Mathematicians in Chicago. On the invitation of Professor Eduard Study, during sabbatic leave in 1906, he delivered a course of lectures on the theory of groups at the University of Bonn. In 1912 Dr. Taber was elected a vice-president of the American Mathematical Society. He became a fellow of this Academy in 1891.

He was married in 1886 to Fanny Lawrence of New York, who died in 1892; they had three daughters who are still living. Of Dr. Taber's brothers, Robert Schell Taber (1865–1904) was a famous actor (Julia Marlowe's first husband), and Edward Martin Taber (1863–1896) an eminent American landscape artist (see R. Cortissoz, *American Artists*, New York, 1923, and S. Isham, *American Painting*, New York, 1927). In appearance Dr. Taber bore such a strong resemblance to the English actor Sir Henry Irving that when he was in London, on being solicited for alms he was addressed as "Sir Henry." He was a member of the Quinsigamond Boat Club, of Worcester, and an excellent tennis player. His religious affiliations were Episcopalian. He had a wide range of interests, and a remarkable memory, and he read widely in other branches of science than his specialty, such as chemistry, physics, and medicine. But he was also a great student of history and anthropology, and took delight in literature, art, music, drama, and dancing (especially Pavlova's). He had a highly developed sense of humor, rejoiced in human contacts, and was ever ready to champion the cause of one whom he felt wronged. An old friend has written to me, "His genial, lighthearted, highstrung personality might easily give a stranger little impression of taking himself seriously. Life was to him what Shakespeare said it is, and his care was to act it beautifully."

R. C. Archibald

FRANK BURSLEY TAYLOR
(1860–1938)

Fellow in Class II, Section I, 1925

Frank Bursley Taylor was son of a leading lawyer of Fort Wayne, Indiana. His father was also a member of the Mississippi River Commission, and his stay at Harvard was co-eval with mine. It is not surprising that his attention was early called to Physiographic problems, so that when his health made indoor work harmful to him he took up with a background of training at Harvard the study of the old shore lines, that surround the Great Lakes and are well marked on Macinac Island, where he had a summer home, and from which he obtained his wife. They traced these shore lines together and in that work I first met him and gave him the first money he ever earned as a professional geologist. With the study of the shore lines it was natural for him to study the ice sheet and its recession upon which they depended for their origin. He became an authority and prepared the Niagara folio of the U. S. Geological Survey tracing the history of Niagara Falls. The origin of glaciation was linked with that of the origin of the earth by T. C. Chamberlin, and Taylor went on to consider the origins of the mountain ranges and this led to the so called Taylor-Wegener hypothesis relative to continental drift. On this he published some ten papers. He also thought a good deal about astronomy and the evolution of the Solar System and published a book. I append letters from him to me of bibliographic interest. He was broad minded enough to change from time to time as he absorbed new facts and was good at drawing maps to illustrate his ideas.

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[1] Dr. Taber's complete Bibliography for the years 1890–97, and analyses of many of his papers, may be found in *Clark University 1889–1899. Decennial Celebration* (Worcester, Mass., 1889), p. 548–549, 73–83; and *Clark University . . . Report of the Presidents and Departments 1916*, p. 12–14. See also Yale University *Obituary Record for the years 1935–1936;* Yale University, *Twenty-fifth Reunion Book of the Class of 1882;* G. L. Randall, *Taber Genealogy. Descendants of Thomas son of Philip Taber*, New Bedford, Mass., 1924, p. 244, 382.

As to his astronomic ideas it is only fair to him to quote from a letter to Leverett as well as to me appended and remark that the publication of the book was forced on him by a well-to-do father who wanted to file a caveat on what he considered his son's great ideas.

In the field connecting geology and cosmogony it is not surprising that his speculations like most others have not been accepted.

On April 24, 1899 he was married to Minnetta Amelia Ketchum who helped him in many ways.

Beside the American Academy he was a Fellow of the American Association for the Advancement of Science, of various local societies and a member and contributor to the Michigan Academy of Science and others.

His memorial as Fellow of the Geological Society of America which includes genealogical data and bibliography was prepared by Frank Leverett with whom he was intimately associated in his work in the Great Lakes region and its glacial and post-glacial geology, and appears in the Proceedings of the Geological Society of America for 1938, pp. 191–200. A shorter abstract appeared in Science, Aug. 5, 1938, p. 121–122, and there were besides the customary newspaper notices a tribute by Agnes Yarnell in the Fort Wayne News Tribune and editorials in the Ft. Wayne Gazette of June 16, and Journal of June 12, and the class memoirs prepared by John C. Merriam, H. U. 1886.

To Leverett's bibliography may be added a posthumous paper in the Scientific monthly (July 1939, Vol. xlix, pp. 49–56) "Geological story of the Great Lakes."

As he wrote to Leverett:

"I am quite free to admit that my efforts to point out the cause of continental crustal movements are largely speculative although I claim to have a few very strong evidences in my favor. But in gathering together the facts that show the character of the crustal movements, and their direction and amount of movement in the several continents I think I have followed much more sound and careful scientific methods."

A. C. Lane

Letters follow:

420 Downing Ave.
Fort Wayne, Ind.
Feb. 14, 1925.

Prof. Alfred C. Lane,
22 Arlington Street,
Cambridge, Mass.

My dear Lane:

Yours of Feb. 3 is received. It is rather funny that you should write just at this time and say the things that you do, for the thing you are after is not yet in existence, but you are just in time probably to get what you want. Here is a little story. The lines you read in the last Who's Who told a lie, thanks to the stubborn meanness of an editor and his advisors, and partly also to my own oversanguine expectations. More than three years ago I prepared two short papers, eleven typewritten pages each under the titles "The Great Satellites of the Giant Planets," and "The Growth of the Planetary System as Revealed in Its Vestiges." I did this in one more desperate effort to get my ideas into a form in which they would be received and published by some scientific journal. I was determined to do no more private printing, except as a last resort. These papers were still in the editor's hands when the last day of grace for Who's Who came. I felt sure the papers would be accepted, but—it simply was a case of counting the eggs before they were hatched. I was disgusted. In my sanguine expectations, I had sent the title in to Who's Who, and then the confounded egg didn't hatch.

Since then I have been working at other things, until a few months ago, when I took up these subjects once more. I think you know the awful struggle I have been thru in endeavoring to formulate my ideas and then to get some one to look at them earnestly and open mindedly. It is more than 40 years (Dec. 13, 1884) since I hit upon the idea of direct capture as the origin of satellites, and I soon extended it to planets. In July 1891, I started to print my ideas privately, but my plan was altogether too elaborate, and I went broke before I got to the real meat of the subject. It was miserable stuff, worse than nothing, and I have always been glad that the attempt failed.

In June, 1898, when my health seemed unusually threatening, I printed privately a little pamphlet of forty pages, a sort of caveat on my ideas, it is no account, excepting as a caveat. The astronomical part is as bad as my earlier attempt, but there are four pages in which I state for the first time my idea of the function of tidal and rotational forces in world-geology, in the making of continents, mountain ranges, etc. This little pamphlet is entitled "An Endogeneous Planetary System." I am sending you a copy herewith, with the geological passage marked. I sent out only three copies of this pamphlet to geologists, one each to Gilbert, McGee and Chamberlin at the time it was printed. About four years ago two copies were sent to non-professional friends, no others were ever sent out. It is a sort of precursor of my later papers on continents, mountain ranges etc. I think I sent you a copy of "Bearing of Tertiary Mountain Belt on the Origin of the Earth's Plan" 1910 long ago. I enclose also a copy of the abstract of my paper at Washington, April 18, 1923 entitled "The Lateral Migration of Land Masses." But if you wish my latest on this theme, see *Pan-American Geologist* for Feb. 1925. In the spring and summer following my father's terrible illness in Boston in Jan. and Feb. 1903, I wrote and printed privately, a book entitled "The Planetary System." This is a fugitive volume if ever there was one, but whether it is a fugitive from justice or from injustice, I have never been able to find out. It has pretty nearly everything it it, but is an awful mess.

About 1908, I began to try to find a way to discuss the growth of the Planetary system by inductive methods (in the Planetary System it was mainly deductive). After more than ten years of study and work, off and on, I produced a paper entitled "The Growth of the Planetary System as revealed in Its Vestiges" and in the Fall of 1920 I sent it to Prof. T. C. Chamberlin for the Journal of Geology. He had published many papers of his own on the same general theme, but he refused mine. Mine, he said, was too astronomical; he advised me to send it to the Astro-physical Journ. (Prof. E. B. Frost, Editor). I knew there was no use to do that, but I did as Chamberlin suggested, just to see what would happen. Frost sent it back and advised me to send it to Chamberlin; so there I was. I recognized that that paper was objectionable because it was too long. But the theme is so big it is next to impossible to present it adequately in short papers. Nevertheless, I tried once more in the two little papers (11 pages each, typewritten) mentioned at the beginning of this letter. They were nicely illustrated. I sent them to the American Journal of Science, but the trip proved to be only an excursion. *Now,* I am in the midst of one more effort to get somewhere with these ideas.

This time I hope to realize it in book form, have a publisher in N. Y. in sight. I have it about half written. I can loan you about half the manuscript for a few days. You may read it and return it as promptly as you can. I may include one of the earlier short papers which I intend to work into the latter part of the present paper. What I send you will cover my main theme fairly well. I enclose pamphlets now; will send you manuscript about Feb. 20.

Very truly yours,
(signed) Frank B. Taylor

December 13th, 1933.

Dear Lane:

Just to remind you that this is the birthday of an idea. On December 13th, 1884, forty-nine years ago today, I first conceived of the idea that the moon became the satellite of the earth by capture directly out of space. I doubt if you have ever been much attracted by my "speculations," but I think I may safely call your attention now to the fact that the world is beginning to come my way, very slowly and only a little, it is true, but while I may not live to see the finish, I think that you with your greater vitality may do so.

You are having your own A. A. A. S. party in Cambridge and I suppose you will stay there and not come to Chicago. I hope to go to the Chicago meeting but am not sure. Good health and a Merry Christmas to all of you.

Yours
(signed) Frank B. Taylor

HARRY WALTER TYLER (1863–1938)

Fellow in Class I, Section 1, 1902

Harry W. Tyler was born in Ipswich, Mass., April 16, 1863, and died in Washington, D. C., Feb. 3, 1938. He was a son of David M. and

Harriet (Wilcomb) Tyler. After graduating in 1884 with the degree of Bachelor of Science, from the Massachusetts Institute of Technology, he was an assistant and instructor in the mathematics department of the Institute for three years. From this period dates a little booklet *Entertainments in Chemistry; Easy Lessons and Directions for Safe Experiments.* In 1887 he was married to Alice Irving Brown of Roxbury, Mass. He spent 1887–88 in study at the University of Göttingen, and 1888–89 at the University of Erlangen, where he obtained the Doctor of Philosophy degree under Gordan, his dissertation being entitled *Beziehungen zwischen der Sylvester'schen und der Bézout'schen Determinante.*

In 1890 he returned to the Institute as an assistant professor of mathematics, became an associate professor in 1892, and was a professor from 1893 till he became professor emeritus in 1930; he was head of the department from 1901, and its high distinction to-day is due in no small degree to the wisdom of appointments which he arranged. Furthermore, it was during the last decade of his regime that 190 numbers of *Contributions* of his department, and ten volumes of the Institute's important quarterly *Journal of Mathematics and Physics*, were published. He served also as registrar, as secretary of the faculty, and for many years as president of the Faculty Club at M. I. T.

Professor Tyler was a constant attendant at meetings of societies and congresses in this country and in Europe and his services as secretary and committee chairman were ever in great demand. In 1893 he was secretary of the first international congress of mathematicians which was held in Chicago. He was chairman of the committee on incorporation of the American Mathematical Society. For many years he was prominent in the Association of University Professors and served as its remarkable general secretary from 1916 to 1934. He was vice-president of the Association for 1934 and 1935 and editor of its *Bulletin* until July 1937. He moved to Washington in 1930, and from that time until his death he was a consultant in science at the Library of Congress. His winning personality won him many friends and he was especially popular with the local alumni group of the Institute which repeatedly elected him as their president.

At congresses he was always an attendant at the sections dealing with pedagogical and historical questions. His *Short History of Science* (New York, 1917) prepared in collaboration with Professor W. T. Sedgwick was the outgrowth of a lecture course given by the authors for several years to undergraduate classes of the Institute. The new edition of 1939, in part a revision but to a great extent a new work, was prepared by Tyler and R. P. Bigelow.

Dr. Tyler had remarkable executive ability, "energy, patience, initiative and caution, firmness and tact, dignity and (not least valuable) a dry and penetrating sense of humor—the expression of which, when such expression would have been inopportune, he was almost always (with some difficulty one suspects) able to restrain."[1] He became a fellow of the Academy in 1902, the year when his fellow mathematicians rated him as 77th among the leading 80 mathematicians of the United States and Canada.

Of his four daughters the eldest, Margaret Tyler, is a physician, and associate clinical professor in obstetrics and gynecology at the Yale University School of Medicine.

R. C. ARCHIBALD

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[1] A. O. Lovejoy, "Harry Walter Tyler 1863–1938," Amer. Assoc. Univ. Prof., *Bulletin*, v. 24, 1938, p. 219–221. See also *Science*, n. s., v. 87, 1938, p. 181.

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11	Dugald Caleb Jackson	Cambridge
30	Frank Baldwin Jewett	New York, N. Y.
01	Lewis Jerome Johnson	Cambridge
37	Joseph Henry Keenan	Belmont
32	Ralph Restieaux Lawrence	Belmont
23	William Henry Lawrence	Jamaica Plain
38	John Moyes Lessells	Brookline
12	Lionel Simeon Marks	Cambridge
44	Richard von Mises	Cambridge
34	Edward Leyburn Moreland	Wellesley
20	Frederick Law Olmsted	Elkton, Md.
28	Langdon Pearse	Chicago, Ill.
13	Harold Pender	Philadelphia, Pa.
30	Greenleaf Whittier Pickard	Newton Center
41	Reinhold Rüdenberg	Belmont
30	George Edmond Russell	Lexington
39	C. Richard Soderberg	Weston
14	Charles Milton Spofford	Boston
[28] 44	Karl Terzaghi	Winchester
23	Edward Pearson Warner	Washington, D. C.
37	Harald Malcolm Westergaard	Belmont
40	John Wulff	Cambridge
41	Vladimir Kosma Zworykin	Princeton, N. J.

CLASS II—NATURAL AND PHYSIOLOGICAL SCIENCES—212

SECTION I—*Geology, Mineralogy, and Physics of the Globe*—47

15	Wallace Walter Atwood	Worcester
41	Alan Mara Bateman	New Haven, Conn.
38	Marland Pratt Billings	Wellesley
21	Norman Levi Bowen	Chicago, Ill.
16	Isaiah Bowman	Baltimore, Md.
33	Charles Franklin Brooks	Milton
29	Kirk Bryan	Cambridge
33	Frank Morton Carpenter	Lexington
93	Henry Helm Clayton	Canton
09	Reginald Aldworth Daly	Cambridge
34	Sterling Price Fergusson	Milton
42	Russell Gibson	Belmont
17	James Walter Goldthwait	Hanover, N. H.
14	Louis Caryl Graton	Cambridge
17	Herbert Ernest Gregory	Honolulu, T. H.
21	William Jackson Humphreys	Washington, D. C.
16	Ellsworth Huntington	New Haven, Conn.
44	Columbus O'Donnell Iselin	Woods Hole
95	Robert Tracy Jackson	Peterborough, N. H.
02	Thomas Augustus Jaggar	Honolulu, T. H.
10	Alfred Church Lane	Cambridge
25	Esper Signius Larsen, Jr.	Belmont
15	Andrew Cowper Lawson	Berkeley, Cal.
43	Lewis Don Leet	Harvard
16	Charles Kenneth Leith	Madison, Wis.
31	George Francis McEwen	La Jolla, Cal.
27	Donald Hamilton McLaughlin	New York, N. Y.
25	Kirtley Fletcher Mather	Newton Center
35	Warren Judson Mead	Belmont
21	John Campbell Merriam	Washington, D. C.
17	William John Miller	Los Angeles, Cal.
32	Frederick Kuhne Morris	Cambridge
34	Walter Harry Newhouse	Melrose
17	Percy Edward Raymond	Lexington
22	Austin Flint Rogers	Palo Alto, Cal.
34	Carl-Gustaf Arvid Rossby	Chicago, Ill.
19	Waldemar Theodore Schaller	Washington, D. C.
12	William Berryman Scott	Princeton, N. J.
11	Hervey Woodburn Shimer	Hingham
41	Chester Stock	Pasadena, Cal.
44	Harald Ulrik Sverdrup	La Jolla, Cal.
17	Thomas Wayland Vaughan	Washington, D. C.
08	Charles Hyde Warren	New Haven, Conn.
14	Herbert Percy Whitlock	New York, N. Y.
35	Derwent Stainthorpe Whittlesey	Cambridge
15	Bailey Willis	Palo Alto, Cal.
15	Frederick Eugene Wright	Washington, D. C.

CLASS II, SECTION II—*Botany*—39

30	LeRoy Abrams	Palo Alto, Cal.
11	Oakes Ames	North Easton
34	Edgar Anderson	St. Louis, Mo.
15	Irving Widmer Bailey	Cambridge
00	Liberty Hyde Bailey	Ithaca, N. Y.
21	Edward Wilber Berry	Baltimore, Md.
40	Albert Francis Blakeslee	Northampton
98	Douglas Houghton Campbell	Palo Alto, Cal.
16	Bradley Moore Davis	Ann Arbor, Mich.
35	Bernard Ogilvie Dodge	New York, N. Y.
41	Arthur Johnson Eames	Ithaca, N. Y.
21	Rollins Adams Emerson	Ithaca, N. Y.
12	Alexander William Evans	New Haven, Conn.
29	Joseph Horace Faull	Cambridge
00	Merritt Lyndon Fernald	Cambridge
44	Paul Rupert Gast	Petersham
11	Robert Almer Harper	Bedford, Va.
98	John George Jack	East Walpole
28	Willis Linn Jepson	Berkeley, Cal.
27	Ivan Murray Johnston	Brookline
34	Donald Forsha Jones	New Haven, Conn.
14	Burton Edward Livingston	Riderwood, Md.
40	Paul Christoph Mangelsdorf	Newtonville
42	William Ralph Maxon	Washington, D. C.
21	Elmer Drew Merrill	Jamaica Plain
10	Winthrop John Vanleuven Osterhout	New York, N. Y.
27	George James Peirce	Palo Alto, Cal.
44	Hugh Miller Raup	Jamaica Plain
14	Alfred Rehder	Jamaica Plain
30	Karl Sax	Forest Hills
34	Edmund Ware Sinnott	New Haven, Conn.
44	Albert Charles Smith	Jamaica Plain
34	Gilbert Morgan Smith	Palo Alto, Cal.
23	Elvin Charles Stakman	St. Paul, Minn.
38	Kenneth Vivian Thimann	Cambridge
92	William Trelease	Urbana, Ill.
31	Charles Alfred Weatherby	Cambridge

22 William Henry Weston, Jr. . . . . Winchester
32 Ralph Hartley Wetmore . . . . Cambridge

Class II, Section III—*Zoology and Physiology*—66

22 Nathan Banks . . . . Holliston
16 Thomas Barbour . . . . Boston
33 Philip Bard . . . . Baltimore, Md.
09 Francis Gano Benedict . . . . Machiasport, Me.
11 Henry Bryant Bigelow . . . . Concord
14 Robert Payne Bigelow . . . . Brookline
35 Charles Henry Blake . . . . Lincoln
20 William T. Bovie . . . . Fairfield, Me.
24 Edward Allen Boyden . . . . Minneapolis, Minn.
16 John Lewis Bremer . . . . Boston
15 Charles Thomas Brues . . . . Newtonville
28 John Wymond Miller Bunker . . . . Belmont
06 Walter Bradford Cannon . . . . Cambridge
22 Thorne Martin Carpenter . . . . West Roxbury
00 William Ernest Castle . . . . Berkeley, Cal.
29 Lemuel Roscoe Cleveland . . . . Jamaica Plain
26 Edwin Joseph Cohn . . . . Cambridge
14 Edwin Grant Conklin . . . . Princeton, N. J.
23 Manton Copeland . . . . Brunswick, Me.
27 William John Crozier . . . . Belmont
17 Joseph Augustine Cushman . . . . Sharon
29 Hallowell Davis . . . . Cambridge
33 Alden Benjamin Dawson . . . . Belmont
25 Samuel Randall Detwiler . . . . New York, N. Y.
43 David Bruce Dill . . . . Washington, D. C.
25 Herbert McLean Evans . . . . Berkeley, Cal.
34 Cyrus Hartwell Fiske . . . . Lexington
15 Alexander Forbes . . . . Milton
34 John Farquhar Fulton . . . . New Haven, Conn.
31 William King Gregory . . . . New York, N. Y.
36 Frederick Lee Hisaw . . . . Belmont
29 Leigh Hoadley . . . . Cambridge
34 Hudson Hoagland . . . . Worcester
24 Samuel Jackson Holmes . . . . Berkeley, Cal.
28 Roy Graham Hoskins . . . . Waban
13 Leland Ossian Howard . . . . Washington, D. C.
14 Herbert Spencer Jennings . . . . Los Angeles, Cal.
13 Charles Atwood Kofoid . . . . Berkeley, Cal.
44 Eugene Markley Landis . . . . Brookline
16 Frederic Thomas Lewis . . . . Waban
33 Frank Rattray Lillie . . . . Chicago, Ill.
14 Ralph Stayner Lillie . . . . Chicago, Ill.
17 Richard Swann Lull . . . . New Haven, Conn.
43 Brenton Reid Lutz . . . . Melrose
84 Edward Laurens Mark . . . . Cambridge
15 Albert Davis Mead . . . . Providence, R. I.
27 Axel Leonard Melander . . . . Riverside, Cal.
35 Karl Friedrich Meyer . . . . San Francisco, Cal.
21 Gerrit Smith Miller . . . . Washington, D. C.
28 Thomas Hunt Morgan . . . . Pasadena, Cal.
42 Hermann Joseph Muller . . . . Amherst
95 George Howard Parker . . . . Cambridge
21 Henry Augustus Pilsbry . . . . Philadelphia, Pa.
39 Gregory Pincus . . . . Worcester
27 Frederick Haven Pratt . . . . Wellesley Hills
09 Herbert Wilbur Rand . . . . Cambridge
32 David Rapport . . . . Cambridge
23 Alfred Clarence Redfield . . . . Cambridge
34 Alfred Newton Richards . . . . Bryn Mawr, Pa.
34 Oscar Riddle . . . . Cold Spring Harbor, N. Y.
37 Alfred Sherwood Romer . . . . Cambridge
25 Alexander Grant Ruthven . . . . . . Ann Arbor, Mich.
41 Francis Otto Schmitt . . . . Belmont
15 Arthur Wisswald Weysse . . . . Woburn
38 George Bernays Wislocki . . . . Milton
33 Jeffries Wyman, Jr. . . . . Chestnut Hill

Class II, Section IV—*Medicine and Surgery*—60

41 Fuller Albright . . . . Brookline
32 Joseph Charles Aub . . . . Belmont
36 Oswald Theodore Avery . . . . New York, N. Y.
29 James Bourne Ayer . . . . Milton
(28) 32 Franklin Greene Balch . . . . Boston
41 Walter Bauer . . . . Waban
31 George Blumer . . . . San Marino, Cal.
43 Arlie Vernon Bock . . . . Cambridge
36 Charles Sidney Burwell . . . . Brookline
19 Alexis Carrel . . . . New York, N. Y.
31 William Bosworth Castle . . . . Brookline
30 David Cheever . . . . Boston
13 Henry Asbury Christian . . . . Brookline
42 William Irving Clark . . . . Worcester
21 Rufus Cole . . . . Mount Kisco, N. Y.
32 Elliott Carr Cutler . . . . Brookline
31 Eugene Floyd DuBois . . . . New York, N. Y.
44 Maxwell Finland . . . . Squantum
33 Reginald Fitz . . . . Brookline
11 Simon Flexner . . . . New York, N. Y.
27 James Lawder Gamble . . . . Brookline
22 Joseph Lincoln Goodale . . . . Ipswich
21 Ross Granville Harrison . . . . New Haven, Conn.
27 Percy Rogers Howe . . . . Belmont
21 William Henry Howell . . . . Baltimore, Md.
33 Edgar Erskine Hume . . . . Frankfort, Ky.
15 Reid Hunt . . . . Boston
34 Henry Jackson, Jr. . . . . Chestnut Hill
12 Elliott Proctor Joslin . . . . Boston
43 Chester Scott Keefer . . . . Brookline
23 Roger Irving Lee . . . . Brookline
42 Samuel Albert Levine . . . . Newton Center
29 Edwin Allen Locke . . . . Williamstown
28 Warfield Theobald Longcope . . . . . . Baltimore, Md.
32 Fred Bates Lund . . . . Newton Center
40 William de Berniere MacNider . . Chapel Hill, N. C.
44 William Malamud . . . . Worcester
34 Leroy Matthew Simpson Miner . . . . Newtonville
26 George Richards Minot . . . . Brookline
41 Alan Richards Moritz . . . . Jamaica Plain
28 William Lorenzo Moss . . . . Athens, Ga.
28 John Howard Mueller . . . . West Roxbury
25 Robert Bayley Osgood . . . . Boston
37 Walter Walker Palmer . . . . New York, N. Y.
27 Joseph Hershey Pratt . . . . Brookline
35 Tracy Jackson Putnam . . . . New York, N. Y.
34 William Carter Quinby . . . . Brookline
34 Arthur Hiler Ruggles . . . . Providence, R. I.

39 Frederick Fuller Russell . . . . Brookline
39 William Thomas Salter . . . . New Haven, Conn.
33 George Cheever Shattuck . . . . Brookline
30 Torald Hermann Sollmann . . . . Cleveland, O.
14 Richard Pearson Strong . . . . Boston
30 Fritz Bradley Talbot . . . . Brookline
44 George Widmer Thorn . . . . Cambridge
14 Ernest Edward Tyzzer . . . . Wakefield
14 Frederick Herman Verhoeff . . . . Brookline
27 Joseph Treloar Wearn . . . . Cleveland, Ohio
40 Paul Dudley White . . . . Brookline
12 Simeon Burt Wolbach . . . . South Sudbury

CLASS III—The Social Arts—174

Section I—*Jurisprudence*—39

(24) 32 Francis Noyes Balch . . . . Jamaica Plain
38 Henry Moore Bates . . . . Ann Arbor, Mich.
36 Stoughton Bell . . . . Cambridge
33 Harry Augustus Bigelow . . . . Chicago, Ill.
36 Wilfred Bolster . . . . Wellesley
36 Claude Raymond Branch . . . . Providence, R. I.
33 John Dickinson . . . . Philadelphia, Pa.
38 Robert Gray Dodge . . . . Boston
31 Fred Tarbell Field . . . . Newton
39 Herbert Funk Goodrich . . . . Philadelphia, Pa.
33 Theodore Francis Green . . . . Providence, R. I.
38 Frank Washburn Grinnell . . . . Boston
41 Erwin Nathaniel Griswold . . . . Belmont
39 John Loomer Hall . . . . Boston
39 Augustus Noble Hand . . . . New York, N. Y.
33 Learned Hand . . . . New York, N. Y.
39 Albert James Harno . . . . Urbana, Ill.
18 Charles Evans Hughes . . . . Washington, D. C.
38 Melvin Maynard Johnson . . . . Brookline
38 James McCauley Landis . . . . Cambridge
32 Sayre Macneil . . . . Pasadena, Cal.
32 Calvert Magruder . . . . Cambridge
31 William DeWitt Mitchell . . . . New York, N. Y.
31 Edmund Morris Morgan . . . . Arlington
36 Henry Parkman, Jr. . . . . Boston
39 Robert Porter Patterson . . . . Washington, D. C.
01 George Wharton Pepper . . . . Philadelphia, Pa.
11 Roscoe Pound . . . . Watertown
38 William Morton Prest . . . . Boston
36 Stanley Elroy Qua . . . . Lowell
32 Francis Bowes Sayre . . . . Washington, D. C.
21 Austin Wakeman Scott . . . . Cambridge
36 Sidney Post Simpson . . . . Cambridge
33 Harlan Fiske Stone . . . . Washington, D. C.
39 Thomas Walter Swan . . . . New York, N. Y.
32 Edward Sampson Thurston . . . . Berkeley, Cal.
38 Bentley Wirt Warren . . . . Boston
(28) 32 Edmund Allen Whitman . . . . Cambridge
43 Charles Edward Wyzanski, Jr. . . . . Cambridge

Class III, Section II—*Government, International Law, and Diplomacy*—28

36 Howard Landis Bevis . . . . Columbus, O.
33 Edwin Montefiore Borchard . . . . New Haven, Conn.
40 Robert Granville Caldwell . . . . Belmont
32 William Richards Castle, Jr. . . . . Washington, D. C.
32 Joseph Perkins Chamberlain . . . . . New York, N. Y.
33 Robert Treat Crane . . . . New York, N. Y.
35 Tyler Dennett . . . . Hague, N. Y.
31 Sidney Bradshaw Fay . . . . Cambridge
27 William Cameron Forbes . . . . Norwood
34 Edgar Stephenson Furniss . . . . . New Haven, Conn.
32 Joseph Clark Grew . . . . Washington, D. C.
35 Charles Grove Haines . . . . Los Angeles, Cal.
41 Hajo Holborn . . . . Hamden, Conn.
27 Arthur Norman Holcombe . . . . Cambridge
31 Manley Ottmer Hudson . . . . Cambridge
32 Philip Carryl Jessup . . . . New York, N. Y.
32 Charles Edward Merriam . . . . Chicago, Ill.
19 John Bassett Moore . . . . New York, N. Y.
13 William Bennett Munro . . . . Pasadena, Cal.
41 Gaetano Salvemini . . . . Cambridge
40 Thomas Head Thomas . . . . Cambridge
44 Sarah Wambaugh . . . . Cambridge
43 Payson Sibley Wild, Jr. . . . . Cambridge
27 Westel Woodbury Willoughby . . Washington, D. C.
32 William Franklin Willoughby . . Washington, D. C.
14 George Grafton Wilson . . . . Grafton, Vt.
27 Quincy Wright . . . . Chicago, Ill.
33 Henry Aaron Yeomans . . . . Harvard

Class III, Section III—*Economics and Sociology*—67

36 James Waterhouse Angell . . . . . . New York, N. Y.
36 James Cummings Bonbright . . . . . New York, N. Y.
43 Augusta Fox Bronner (Mrs. William Healy)
Boston
44 Douglass Vincent Brown . . . . Brookline
33 Harold Hitchings Burbank . . . . Cambridge
34 John Maurice Clark . . . . Westport, Conn.
28 Arthur Harrison Cole . . . . Cambridge
31 Melvin Thomas Copeland . . . . Cambridge
31 William Leonard Crum . . . . Cambridge
32 William James Cunningham . . . . Cambridge
21 Clive Day . . . . New Haven, Conn.
32 Arthur Stone Dewing . . . . Newton
41 Carl Rupp Doering . . . . Cambridge
32 Wallace Brett Donham . . . . Cambridge
34 John Franklin Ebersole . . . . Belmont
42 Howard Sylvester Ellis . . . . Berkeley, Cal.
36 Fred Rogers Fairchild . . . . Hamden, Conn.
36 Frank Albert Fetter . . . . Princeton, N. J.
12 Irving Fisher . . . . New Haven, Conn.
34 Ralph Evans Freeman . . . . Cambridge
13 Edwin Francis Gay . . . . San Marino, Cal.
33 Sheldon Glueck . . . . Cambridge
39 Gottfried Haberler . . . . Cambridge
34 Robert Murray Haig . . . . New York, N. Y.
41 Earl Jefferson Hamilton . . . . Evanston, Ill.
32 Henry Wyman Holmes . . . . Cambridge
34 Edwin Walter Kemmerer . . . . Princeton, N. J.
34 Frank Hyneman Knight . . . . Chicago, Ill.
42 Wassily W. Leontief . . . . Cambridge
36 Roswell Cheney McCrea . . . . Augusta, Ga.
34 Robert Morison MacIver . . . . New York, N. Y.

32	Walter Wallace McLaren	Williamstown
36	Malcolm Perrine McNair	Cambridge
32	Leon Carroll Marshall	Chevy Chase, Md.
33	Edward Sagendorph Mason	Cambridge
36	Elton Mayo	Cambridge
34	Richard Stockton Meriam	South Lincoln
34	Harry Alvin Millis	Washington, D. C.
32	Frederick Cecil Mills	New York, N. Y.
31	Wesley Clair Mitchell	New York, N. Y.
34	Arthur Eli Monroe	Cambridge
32	Harolk Glenn Moulton	Washington, D. C.
34	Edwin Griswold Nourse	Washington, D. C.
32	William Fielding Ogburn	Chicago, Ill.
42	William Andrew Paton	Ann Arbor, Mich.
32	Leo S. Rowe	Washington, D. C.
37	Clyde Orval Ruggles	Cambridge
42	Paul Anthony Samuelson	Cambridge
36	Thomas Henry Sanders	Cambridge
33	Josef Alois Schumpeter	Cambridge
43	Benjamin Morris Selekman	Cambridge
32	Carl Snyder	New York, N. Y.
31	Pitirim Alexandrovich Sorokin	Winchester
41	Francis Trow Spaulding	Cambridge
31	Oliver Mitchell Wentworth Sprague	Cambridge
34	Frederick John Teggart	Berkeley, Cal.
33	William Isaac Thomas	Berkeley, Cal.
37	Harry Rudolph Tosdal	Belmont
31	Donald Skeele Tucker	Belmont
41	Robert Ulich	Cambridge
33	Abbott Payson Usher	Salem
34	Jacob Viner	Chicago, Ill.
38	T[homas] North Whitehead	Cambridge
32	John Henry Williams	Cambridge
36	Joseph Henry Willits	New York, N. Y.
34	Leo Wolman	New York, N. Y.
34	Carle Clark Zimmerman	Winchester

CLASS III, SECTION IV—*Administration and Affairs*—40

(25) 32	Charles Francis Adams	Concord
39	Chester Irving Barnard	Newark, N. J.
(25) 32	Charles Foster Batchelder	Peterborough, N. H.
44	Adolf Augustus Berle, Jr.	Washington, D. C.
44	Raymond Blaine Fosdick	New York, N. Y.
41	Godfrey Lowell Cabot	Boston
43	Ada Louise Comstock (Mrs. Wallace Notestein)	New Haven, Conn.
42	Donald Kirk David	Boston
38	Edmund Ezra Day	Ithaca, N. Y.
41	Frederic Adrian Delano	Washington, D. C.
32	Henry Sturgis Dennison	Framingham
(28) 32	William Lusk Webster Field	Milton
39	Ralph Edward Flanders	Springfield, Vt.
38	Horace Sayford Ford	Belmont
35	Jerome Davis Greene	Cambridge
42	Roger Sherman Greene	Worcester
44	Ernest Martin Hopkins	Hanover, N. H.
(28) 32	Edward Jackson Holmes	Topsfield
41	Edward Godfrey Huber	Waban
34	Henry Plimpton Kendall	Sharon
44	James Rhyne Killian, Jr.	Wellesley Hills
32	Thomas William Lamont	New York, N. Y.
39	Morris Evans Leeds	Philadelphia, Pa.
34	Clarence Cook Little	Bar Harbor, Me.
36	Dumas Malone	Charlottesville, Va.
42	Daniel L. Marsh	Boston
33	James Vance May	Watertown
02	Herbert Putnam	Washington, D. C.
34	Erwin Haskell Schell	Cambridge
38	Charles Seymour	New Haven, Conn.
35	Henry Lee Shattuck	Boston
37	Henry Southworth Shaw	Melrose
(28) 32	Payson Smith	Orono, Me.
33	Albert Warren Stearns	Billerica
36	Clair Elsmere Turner	Arlington
(24) 32	Edwin Sibley Webster	Brookline
44	Charles Edward Wilson	New York
41	Laurence Leathe Winship	South Sudbury
(25) 32	Benjamin Loring Young	Weston
39	Owen D. Young	New York, N. Y.

CLASS IV—THE HUMANITIES—187

SECTION I—*Theology, Philosophy, and Psychology*—40

32	Michael Joseph Ahern	Weston
32	James Rowland Angell	Hamden, Conn.
33	John Gilbert Beebe-Center	Swampscott
38	Julius Seelye Bixler	Waterville, Me.
24	Edwin Garrigues Boring	Cambridge
28	Edgar Sheffield Brightman	Newton
31	Henry Addington Bruce	Cambridge
32	Leonard Carmichael	Tufts College
36	Robert Pierce Casey	Providence, R. I.
28	Walter Fenno Dearborn	Cambridge
18	Edmund Burke Delabarre	Providence, R. I.
33	Curt John Ducasse	Providence, R. I.
43	Angus Dun	Washington, D. C.
38	James Everett Frame	Princeton, N. J.
37	Clarence Henry Graham	Providence, R. I.
30	William Henry Paine Hatch	Cambridge
32	William Healy	Natick
35	Clark Leonard Hull	New Haven, Conn.
33	Walter Samuel Hunter	Providence, R. I.
28	Albert Cornelius Knudson	Cambridge
32	Karl Spencer Lashley	Orange Park, Fla.
29	Clarence Irving Lewis	Lexington
42	Richard Peter McKeon	Chicago, Ill.
35	Henry Alexander Murray, Jr.	Boston
32	Arthur Darby Nock	Cambridge
28	Johnson O'Connor	Boston
17	Charles Edwards Park	Boston
33	Carroll Cornelius Pratt	New Brunswick, N. J.
30	James Hugh Ryan	Omaha, Neb.
31	Henry Knox Sherrill	Boston
27	Willard Learoyd Sperry	Cambridge
29	Russell Henry Stafford	Brookline
34	Lewis Madison Terman	Belmont
34	Edward Lee Thorndike	Montrose, N. Y.
37	Louis Leon Thurstone	Chicago, Ill.

28	Henry Bradford Washburn	Cambridge
17	John Broadus Watson	New York, N. Y.
33	Frederic Lyman Wells	Newton Highlands
35	Robert Sessions Woodworth	New York, N. Y.
15	Robert Mearns Yerkes	New Haven, Conn.

CLASS IV, SECTION II—*History, Archaeology, and Anthropology*—43

41	Warren Ortman Ault	Waban
28	James Phinney Baxter, 3d	Williamstown
23	Carl Lotus Becker	Ithaca, N. Y.
27	Robert Pierpont Blake	Cambridge
39	Crane Brinton	Cambridge
42	Henry Joel Cadbury	Cambridge
(25) 32	William Brooks Cabot	Boston
34	Clarence Gordon Campbell	New York, N. Y.
12	George Henry Chase	Cambridge
44	William Bell Dinsmoor	New York, N. Y.
21	Max Farrand	Bar Harbor, Me.
21	William Scott Ferguson	Cambridge
38	Allyn Bailey Forbes	Cambridge
33	Henry Thatcher Fowler	Harmony, R. I.
38	Claude Moore Fuess	Andover
18	Evarts Boutell Greene	Croton-on-Hudson, N. Y.
43	Hugh O'Neill Hencken	Chestnut Hill
14	Bert Hodge Hill	Athens, Greece
27	Earnest Albert Hooton	Cambridge
33	Halford Lancaster Hoskins	Medford
44	Clyde Kay Maben Kluckhohn	Cambridge
12	Alfred Louis Kroeber	Berkeley, Cal.
15	Kirsopp Lake	So. Pasadena, Cal.
44	Ambrose Lansing	New York, N. Y.
22	George La Piana	Cambridge
32	Waldo Gifford Leland	Washington, D. C.
41	William E. Lingelbach	Philadelphia, Pa.
20	Charles Howard McIlwain	Belmont
14	Roger Bigelow Merriman	Cambridge
38	Stewart Mitchell	Gloucester
15	Samuel Eliot Morison	Canton
34	Robert Henry Pfeiffer	Cambridge
34	David Moore Robinson	Baltimore, Md.
23	Michael Ivanovich Rostovtzeff	New Haven, Conn.
27	George Sarton	Cambridge
38	Bernadotte Everly Schmitt	Chicago, Ill.
36	Donald Scott	Cambridge
34	Theodore Leslie Shear	Princeton, N. J.
26	Herbert Joseph Spinden	Brooklyn, N. Y.
32	Charles Holt Taylor	Cambridge
11	Alfred Marston Tozzer	Cambridge
39	Henry Rouse Viets	Dedham
20	Clark Wissler	New York, N. Y.

CLASS IV, SECTION III—*Philology*—55

33	William Nickerson Bates	Philadelphia, Pa.
35	Charles Henry Beeson	Chicago, Ill.
33	Campbell Bonner	Ann Arbor, Mich.
35	Robert Johnson Bonner	Chicago, Ill.
41	Giusepps Antonio Borgese	Chicago, Ill.
21	Carl Darling Buck	Chicago, Ill.
18	Edward Capps	Princeton, N. J.
20	Walter Eugene Clark	Cambridge
32	Ronald Salmon Crane	Chicago, Ill.
32	Morris William Croll	Princeton, N. J.
44	Henry Grattan Doyle	Washington, D. C.
20	Franklin Edgerton	New Haven, Conn.
40	Serge Elisséeff	Cambridge
14	Jeremiah Denis Mathias Ford	Cambridge
30	James Geddes, Jr.	Brookline
16	Louis Herbert Gray	New York, N. Y
25	William Chase Greene	Cambridge
13	Charles Burton Gulick	Cambridge
34	Austin Morris Harmon	New Haven, Conn.
31	Raymond Dexter Havens	Baltimore, Md.
38	Richmond Laurin Hawkins	Cambridge
18	George Lincoln Hendrickson	New Haven, Conn.
17	William Guild Howard	Cambridge
40	Werner Wilhelm Jaeger	Watertown
32	(Ralph) Hayward Keniston	Ann Harbor, Mich.
34	Roland Grubb Kent	Wynnewood, Pa.
33	Hans Kurath	Providence, R. I.
39	Henry Carrington Lancaster	Baltimore, Md.
32	Ernest Felix Langley	Cambridge
33	Ivan Mortimer Linforth	Berkeley, Cal.
44	Elias Avery Lowe	Princeton, N. J.
11	Albert Matthews	Boston
35	Benjamin Dean Meritt	Princeton, N. J.
43	Perry Gilbert Eddy Miller	Cambridge
28	William Albert Nitze	Los Angeles, Cal.
32	George Rapall Noyes	Berkeley, Cal.
34	William Abbott Oldfather	Urbana, Ill.
33	Howard Rollin Patch	Northampton
32	Arthur Stanley Pease	Cambridge
11	Fred Norris Robinson	Cambridge
38	Hyder Edward Rollins	Cambridge
31	Robert Kilburn Root	Princeton, N. J.
35	Henry Arthur Sanders	Ann Arbor, Mich.
18	Rudolph Schevill	Berkeley, Cal.
43	Jean Joseph Seznec	Cambridge
32	Horatio Elwin Smith	New York, N. Y.
39	John Strong Perry Tatlock	Berkeley, Cal.
32	William Thomson	So. Lincoln
11	Charles Cutler Torrey	New Haven, Conn.
44	La Rue Van Hook	New York, N. Y.
33	George Benson Weston	Cambridge
30	Ernest Hatch Wilkins	Oberlin, Ohio
33	Harry Austryn Wolfson	Cambridge
39	William Hoyt Worrell	Ann Arbor, Mich.

CLASS IV, SECTION IV—*The Fine Arts and Belles Lettres*—50

43	Leonard Bacon	Peace Dale, R. I.
26	Frank Weston Benson	Salem
32	(William) Welles Bosworth	Locust Valley, N. Y.
42	John Nash Douglas Bush	Cambridge
33	John Alden Carpenter	Chicago, Ill.
43	Willa Sibert Cather	New York, N. Y.
32	Chalmers Dancy Clifton	New York, N. Y.
32	Kenneth John Conant	Cambridge
34	Charles Jay Connick	Newtonville
29	Charles Townsend Copeland	Cambridge

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41 Archibald Thompson Davison............Lincoln
32 George Harold Edgell................Cambridge
21 William Emerson...................Cambridge
30 John Erskine..................New York, N. Y.
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31 Robert Frost.............South Shaftsbury, Vt.
27 Wallace Goodrich..................Manchester
44 Walter Gropius........................Lincoln
36 William Clifford Heilman............Cambridge
29 Edward Burlingame Hill.............Cambridge
31 Robert Silliman Hillyer..............Cambridge
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38 Joseph Hudnut........................Boston
18 Archer Milton Huntington......New York, N. Y.
31 Henry James..................New York, N. Y.
38 Howard Mumford Jones.............Cambridge
42 Otto Kinkeldey.....................Ithaca, N. Y.
33 Leo Rich Lewis....................Tufts College
21 John Livingston Lowes...............Cambridge
21 Charles Donagh Maginnis...............Brookline
31 Paul Manship................New York, N. Y.
31 Daniel Gregory Mason..........New York, N. Y.
31 Frank Jewett Mather...Washington Crossing, Pa.
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31 Kenneth Ballard Murdock...............Boston
14 William Allan Neilson........Falls Village, Conn.
28 Curtis Hidden Page...........Gilmanton, N. H
(24) 32 Anthony John Philpott............Arlington
41 Walter Hamor Piston, Jr...............Belmont
21 Chandler Rathfon Post...............Cambridge
22 Paul Joseph Sachs...................Cambridge
14 Ellery Sedgwick.........................Boston
19 Henry Dwight Sedgwick...............Dedham
33 David Stanley Smith.........Woodbridge, Conn.
39 Francis Henry Taylor..........New York, N. Y.
43 Randall Thompson...........Charlottesville, Va.
44 Karl Viëtor.........................Cambridge
39 Karl Ephraim Weston.............Williamstown
44 Herbert Eustis Winlock.........New York, N. Y.
22 Charles Henry Conrad Wright.........Cambridge

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13 Edward Kennard Rand...............Cambridge

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34	Ronald Aylmer Fisher	Harpenden, Herts
20	Jacques Salomon Hadamard	Princeton, N. J.
21	Godfrey Harold Hardy	Cambridge, England
27	Ejnar Hertzsprung	Leyden
15	Charles Jean de la Vallee Poussin	Louvain
29	Hermann Weyl	Princeton, N. J.

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24	Albert Einstein	Princeton, N. J.
29	James Franck	Chicago, Ill.
29	Abram F. Joffé	Leningrad
28	Freidrich Paschen	Charlottenburg
14	Max Planck	Berlin

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29	Johannes N. Brönsted	Copenhagen
27	Peter Debye	Ithaca, N. Y.
33	Jaroslav Heyrovsky	Prague
33	Fritz Paneth	Durham
38	Leopold Ruzicka	Zürich
38	Nevil Vincent Sidgwick	Oxford
29	Heinrich Wieland	Munich

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29	Ludwig Prandtl	Göttingen
29	Emil Probst	Oxford
29	Aurel Stodola	Zürich
31	Karl Willy Wagner	Berlin

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18	Sir William Napier Shaw	London

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27	Sir Henry Hallett Dale	London
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38	Kenzo Takayanagi	Tokyo

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38	B. Seebohm Rowntree	North Dean, Bucks

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32	Pierre Janet	Paris
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37	Henri Piéron	Paris

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40	Martin Persson Nilsson	Lund
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17	Ramón Menéndez Pidal	Madrid
32	Frederick William Thomas	Oxford

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40	Paul Hindemith	New Haven, Conn.
34	Serge Koussevitzky	Boston
27	Gilbert Murray	Oxford
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41	Jan Sibelius	Helsinki
40	Igor Stravinsky	Paris

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Hovgaard, W. F, I: 4
Howard, L. O. F, II: 3
Howard, W. G. F, IV: 3
Howe, M. A. DeW. F, IV: 4
Howe, P. R. F, II: 4
Howell, W. H. F, II: 4
Hu Shih. FHM, III: 2
Hubbard, J. C. F, I: 2
Huber, E. G. F, III: 4
Hudnut, J. F, IV: 4
Hudson, M. O. F, III: 2
Hughes, C. E. F, III: 1
Hull, C. L. F, IV: 1
Hull, G. F. F, I: 2
Hume, E. E. F, II: 4
Humphreys, W. J. F, II: 1
Hunsaker, J. C. F, I: 4
Hunt, F. V. F, I: 2
Hunt, R. F, II: 4
Hunter, W. S. F, IV: 1
Huntington, A. M. F, IV: 4
Huntington, E. F, II: 1
Huntington, E. V. F, I: 1
Huntress, E. H. F, I: 3
Husserl, E. FHM, IV: 1
Iselin, C. O. F, II: 1
Jack, J. G. F, II: 2
Jack, J. R. F, I: 4
Jackson, C. N. FE, IV: 3
Jackson, D. F, I: 1
Jackson, D. C. F, I: 4
Jackson, H., Jr. F, II: 4
Jackson, R. T. F, II: 1
Jacobi, H. G. FHM, IV: 3
Jaeger, W. W. F, IV: 3
Jaggar, T. A. F, II: 1
James, H. F, IV: 4
Janet, P. FHM, IV: 1
Jellinek, E. M. F, I: 1
Jennings, H. S. F, II: 3
Jepson, W. L. F, II: 2
Jessup, P. C. F, III: 2
Jewett, F. B. F, I: 4
Joffé, A. F. FHM, I: 2
Johnson, L. J. F, I: 4
Johnson, M. M. F, III: 1
Johnston, I. M. F, II: 2
Jones, D. F. F, II: 2
Jones, G. F, I: 3
Jones, H. M. F, IV: 4
Joslin, E. P. F, II: 4
Keefer, C. S. F, II: 4
Keenan, J. H. F, I: 4
Keith, Sir A. FHM, II: 4
Kelsen, H. FHM, III: 1
Kemble, E. C. F, I: 2
Kemmerer, E. W. F, III: 3
Kendall, H. P. F, III: 4
Keniston, H. F, IV: 3
Kent, R. G. F, IV: 3

Keyes, F. G. F, I: 3
Keynes, Baron. FHM, III: 3
Killian, J. R., Jr. F, III: 4
Kindelkey, O. F, IV: 4
King, R. W. P. F, I: 2
Kistiakowsky, G. B. F, I: 3
Kluckhohn, C. K. M. F, IV: 2
Knight, F. H. F, III: 3
Knudson, A. C. F, IV: 1
Köhler, W. FHM, IV: 1
Kofoid, C. A. F, II: 3
Koussevitzky, S. FHM, IV: 4
Kraus, C. A. F, I: 3
Kretschmer, P. FHM, IV: 3
Kroeber, A. L. F, IV: 2
Krogh, A. FHM, II: 3
Kurath, H. F, IV: 3
Lake, K. F, IV: 2
Lamb, A. B. F, I: 3
Lamont, T. W. F, III: 4
Lampland, C. O. F, I: 1
Lancaster, H. C. F, IV: 3
Land, E. H. F, I: 2
Landis, E. M. F, II: 3
Landis, J. M. F, III: 1
Lane, A. C. F, II: 1
Langley, E. F. F, IV: 3
Langmuir, I. F, I: 3
Lansing, A. F, IV: 2
La Piana, G. F, IV: 2
Lapicque, L. E. FHM II: 3
Larsen, E. S. F, II: 1
Lashley, K. S. F, IV: 1
Lawrence, E. O. F, I: 2
Lawrence, R. R. F, I: 4
Lawrence, W. H. F, I: 4
Lawson, A. C. F, II: 1
Lee, R. I. F, II: 4
Leeds, M. E. F, III: 4
Leet, L. D. F, II: 1
Lefavour, H. F, I: 2
Leith, C. K. F, II: 1
Leland, W. G. F, IV: 2
Leontief, W. W. F, III: 3
Lessells, J. M. F, I: 4
Levine, S. A. F, II: 4
Lewis, C. I. F, IV: 1
Lewis, F. T. F, II: 3
Lewis, G. N. F, I: 3
Lewis, L. R. F, IV: 4
Lewis, W. K. F, I: 3
Lillie, F. R. F, II: 3
Lillie, R. S. F, II: 3
Lindsay, R. B. F, I: 2
Linforth, I. M. F, IV: 3
Lingelbach, W. E. F, IV: 2
Little, C. C. F, III: 4
Livingston, B. E. F, II: 2
Locke, E. A. F, II: 4
Lombardi, L. FHM, I: 4

Longcope, W. T. F, II: 4
Lowe, E. A. F, IV: 3
Lowes, J. L. FE, IV: 4
Lull, R. S. F, II: 3
Lund, F. B. F, II: 4
Lutz, B. R. F, II: 3
Luyten, W. J. F, I: 1
Lyman, T. F, I: 2
McCrea, R. C. F, III: 3
McEwen, G. F. F, II: 1
McIlwain, C. H. F, IV: 2
MacInnes, D. A. F, I: 3
MacIver, R. M. F, III: 3
McKeehan, L. W. F, I: 2
McKeon, R. P. F, IV: 1
MacLane, S. F, I: 1
McLaren, W. W. F, III: 3
McLaughlin, D. H. F, II: 1
Macmillan, Lord. FHM, III: 1
McNair, M. P. F, III: 3
Macneil, S. F, III: 1
MacNider, W. de B. F, II: 4
Maginnis, C. D. F, IV: 4
Magruder, C. F, III: 1
Makarewicz, J. FHM, III: 1
Malone, D. F, III: 4
Malamud, W. F, II: 4
Mangelsdorf, P. C. F, II: 2
Manship, P. F, IV: 4
Margerie, E. de. FHM, II: 1
Mark, E. L. F, II: 3
Mark, K. L. F, I: 3
Marks, L. S. F, I: 4
Marsh, D. L. F, III: 4
Marshall, L. C. F, III: 3
Mason, D. G. F, IV: 4
Mason, E. S. F, III: 3
Mather, F. J. F, IV: 4
Mather, K. F. F, II: 1
Matthews, A. F, IV: 3
Maunier, R. FHM, III: 3
Maxon, W. R. F, II: 2
May, J. V. F, III: 4
Mayo, E. F, III: 3
Mazon, P. FHM, IV: 3
Mead, A. D. F, II: 3
Mead, W. J. F, II: 1
Mees, C. E. K. F, I: 3
Meinecke, F. FHM, IV: 2
Melander, A. L. F, II: 3
Menzel, D. H. F, I: 1
Meriam, R. S. F, III: 3
Meritt, B. D. F, IV: 3
Merriam, C. E. F, III: 2
Merriam, J. C. F, II: 1
Merrill, E. D. F, II: 2
Merriman, R. B. F, IV: 2
Merritt, E. G. F, I: 2
Meyer, K. F. F, II: 3
Milas, N. A. F, I: 3
Miller, G. A. F, I: 1
Miller, G. S. F, II: 3
Miller, J. A. F, I: 1
Miller, P. G. E. F, IV: 3
Miller, W. J. F, II: 1
Millikan, R. A. F, I: 2
Millis, H. A. F, III: 3
Mills, F. C. F, III: 3
Mimno, H. R. F, I: 2
Miner, L. M. S. F, II: 4
Minot, G. R. F, II: 4
Mises, R. von. F, I: 4
Mitchell, S. F, IV: 2
Mitchell, S. A. F, I: 1
Mitchell, W. C. F, III: 3
Mitchell, W. DeW. F, III: 1
Miyabe, K. FHM, II: 2
Miyajima, M. FHM, II: 4
Molengraaff, G. A. F. FHM, II: 1
Monroe, A. E. F, III: 3
Moore, J. B. F, III: 2
Moreland, E. L. F, I: 4
Morey, C. R. F, IV: 4
Morgan, E. M. F, III: 1
Morgan, T. H. F, II: 3
Morison, S. E. F, IV: 2
Moritz, A. R. F, II: 4
Morris, F. K. F, II: 1
Morse, M. F, I: 1
Morse, P. M. F, I: 2
Morton, A. A. F, I: 3
Moss, W. L. F, II: 4
Moulton, F. R. F, I: 1
Moulton, H. G. F, III: 3
Mueller, E. F, I: 3
Mueller, J. H. F, II: 4
Muller, H. J. F, II: 3
Munro, W. B. F, III: 2
Murdock, K. B. F, IV: 4
Murray, G. FHM, IV: 4
Murray, H. A., Jr. F, IV: 1
Neilson, W. A. F, IV: 4
Neumann, J. von. F, I: 1
Newhouse, W. H. F, II: 1
Nilsson, M. P. FHM, IV: 2
Nitze, W. A. F, IV: 3
Nock, A. D. F, IV: 1
Nourse, E. G. F, III: 3
Noyes, G. R. F, IV: 3
Noyes, W. A., Jr. F, I: 3
O'Connor, J. F, IV: 1
Oertel, H. FHM, IV: 3
Ogburn, W. F. F, III: 3
Oldenberg, O. F, I: 2
Oldfather, W. A. F, IV: 3
Olmsted, F. L. F, I: 4
Oppenheimer, J. R. F, I: 2
Ordoñez, E. FHM, II: 1
Osgood, R. B. F, II: 4
Osterhout, W. J. V. F, II: 2
Page, C. H. F, IV: 4
Page, L. F, I: 2
Palmer, W. W. F, II: 4
Paneth, F. FHM, I: 3
Park, C. E. F, IV: 1
Parker, G. H. F, II: 3
Parkman, H., Jr. F, III: 1
Parodi, L. R. FHM, II: 2
Paschen, F. FHM, I: 2
Patch, H. R. F, IV: 3
Paton, W. A. F, III: 3
Patterson, R. P. F, III: 1
Pauling, L. C. F, I: 3
Payne-Gaposchkin, C. F, I: 1
Pearse, L. F, I: 4
Pease, A. S. F, IV: 3
Peers, E. A. FHM, IV: 4
Peirce, G. J. F, II: 2
Pender, H. F, I: 4
Pepper, G. W. F, III: 1
Pfeiffer, R. H. F, IV: 2
Phillips, H. B. F, I: 1
Philpott, A. J. F, IV: 4
Pickard, G. W. F, I: 4
Pidal, R. M. FHM, IV: 3
Pierce, G. W. F, I: 2
Piéron, H. FHM, IV: 1
Pigou, A. C. FHM, III: 3
Pilsbry, H. A. F, II: 3
Pincus, G. F, II: 3
Piston, W. H. F, IV: 4
Planck, M. FHM, I: 2
Poor, C. L. F, I: 1
Post, C. R. F, IV: 4
Pound, R. F, III: 1
Prandtl, L. FHM, I: 4
Pratt, C. C. F, IV: 1
Pratt, F. H. F, II: 3
Pratt, J. H. F, II: 4
Prescott, S. C. F, I: 3
Prest, W. M. F, III: 1
Probst, E. FHM, I: 4
Purves, C. B. F, I: 3
Putnam, H. F, III: 4
Putnam, T. J. F, II: 4
Qua, S. E. F, III: 1
Quinby, W. C. F, II: 4
Rabaud, H. FHM, IV: 4
Rabi, I. I. F, I: 2
Rand, E. K. FE, IV: 3
Rand, H. W. F, II: 3
Rapport, D. F, II: 3
Raup, H. M. F, II: 2
Raymond, P. E. F, II: 1
Redfield, A. C. F, II: 3
Rehder, A. F, II: 2
Renner, O. FHM, II: 2
Richards, A. N. F, II: 3
Richards, R. H. F, I: 3
Richardson, R. G. D. F, I: 1

Riddle, O. F, II: 3
Rist, C. FHM, III: 3
Robinson, D. M. F, IV: 2
Robinson, F. N. F, IV: 3
Rogers, A. F. F, II: 1
Rollins, H. E. F, IV: 3
Romer, A. S. F, II: 3
Root, R. K. F, IV: 3
Rosanoff, M. A. F, I: 3
Rossby, C. G. A. F, II: 1
Rostovtzeff, M. I. F, IV: 2
Rowe, L. S. F, III: 3
Rowntree, B. S. FHM, III: 4
Rüdenberg, R. F, I: 4
Ruggles, A. H. F, II: 4
Ruggles, C. O. F, III: 3
Russell, F. F. F, II: 4
Russell, G. E. F, I: 4
Russell, H. N. F, I: 1
Ruthven, A. G. F, II: 3
Ruzicka, L. FHM, I: 3
Ryan, J. H. F, IV: 1
Sachs, P. J. F, IV: 4
Salter, W. T. F, II: 4
Salvemini, G. F, III: 2
Samuelson, P. A. F, III: 3
Sanders, H. A. F, IV: 3
Sanders, T. H. F, III: 3
Sarton, G. F, IV: 2
Sax, K. F, II: 2
Sayre, F. B. F, III: 1
Scatchard, G. F, I: 3
Schaller, W. T. F, II: 1
Schell, E. H. F, III: 4
Schevill, R. F, IV: 3
Schmitt, B. E. F, IV: 2
Schmitt, F. O. F, II: 3
Schumb, W. C. F, I: 3
Schumpeter, J. A. F, III: 3
Scott, A. W. F, III: 1
Scott, D. F, IV: 2
Scott, W. B. F, II: 1
Sedgwick, E. F, IV: 4
Sedgwick, H. D. F, IV: 4
Selekman, B. M. F, III: 3
Seymour, C. F, III: 4
Seznec, J. J. F, IV: 3
Shapley, H. F, I: 1
Shattuck, G. C. F, II: 4
Shattuck, H. L. F, III: 4
Shaw, H. S. F, III: 4
Shaw, Sir W. N. FHM, II: 1
Shear, T. L. F, IV: 2
Sherrill, H. K. F, IV: 1
Sherrill, M. S. F, I: 3
Sherrington, Sir C. S. FHM, II: 4
Shimer, H. W. F, II: 1
Sibelius, J. FHM, IV: 4
Sidgwick, N. V. FHM, I: 3
Simpson, S. P. F, III: 1
Sinnott, E. W. F, II: 2
Slater, J. C. F, I: 2
Slipher, V. M. F, I: 1
Slocum, F. F, I: 1
Smith, A. C. F, II: 2
Smith, D. S. F, IV: 4
Smith, G. M. F, II: 2
Smith, H. E. F, IV: 3
Smith, H. M. F, I: 3
Smith, L. B. F, I: 3
Smith, P. F, III: 4
Smith, Sir W. W. FHM, II: 2
Snyder, C. F, III: 3
Snyder, V. F, I: 1
Soderberg, R. C. F, I: 4
Sollmann, T. H. F, II: 4
Sorokin, P. A. F, III: 3
Spaulding, F. T. F, III: 3
Sperry, W. L. F, IV: 1
Spinden, H. J. F, IV: 2
Spofford, C. M. F, I: 4
Sprague, O. M. W. F, III: 3
Stafford, R. H. F, IV: 1
Stakman, E. C. F, II: 2
Stammler, R. FHM, II: 1
Stearns, A. W. F, III: 4
Stebbins, J. F, I: 1
Steinmetz, S. R. FHM, III: 3
Stetson, H. T. F, I: 1
Stewart, G. W. F, I: 2
Stock, C. F, II: 1
Stockbarger, D. C. F, I: 2
Stodola, A. FHM, I: 4
Stone, H. F. F, III: 1
Stravinsky, I. FHM, IV: 4
Street, J. C. F, I: 2
Strong, R. P. F, II: 4
Struik, D. J. F, I: 1
Struve, O. F, I: 1
Struve, P. B. FHM, III: 3
Sverdrup, H. U. F, II: 1
Swan, T. W. F, III: 1
Takayanagi, K. FHM, III: 1
Talbot, F. B. F, II: 4
Tamarkin, J. D. F, I: 1
Tatlock, J. S. P. F, IV: 3
Taylor, C. H. F, IV: 2
Taylor, F. H. F, IV: 4
Taylor, H. S. F, I: 2
Teggart, F. J. F, III: 3
Terman, L. M. F, IV: 1
Terzaghi, K. F, I: 4
Thimann, K. V. F, II: 2
Thomas, F. W. FHM, IV: 3
Thomas, T. H. F, III: 2
Thomas, W. I. F, III: 3
Thompson, Sir D'A. W. FHM, II: 3
Thompson, M. deK. F, I: 2
Thompson, R. F, IV: 4
Thomson, W. F, IV: 3
Thorn, G. W. F, II: 4
Thorndike, E. L. F, IV: 1
Thurston, E. S. F, III: 1
Thurstone, L. L. F, IV: 1
Tolman, R. C. F, I: 3
Torrey, C. C. F, IV: 3
Tosdal, H. R. F, III: 3
Tozzer, A. M. F, IV: 2
Trelease, W. F, II: 2
Trevelyan, G. M. FHM, IV: 2
Tucker, D. S. F, III: 3
Turner, C. E. F, III: 4
Tyzzer, E. E. F, II: 4
Ulich, R. F, III: 3
Urey, H. C. F, I: 3
Usher, A. P. F, III: 3
Vallarta, M. S. F, I: 2
Vallée Poussin, C. J. de la. FHM, I: 1
Van de Graaff, R. J. F, I: 2
Van Hook, L. R. F, IV: 3
Van Vleck, J. H. F, I: 2
Vaughan, T. W. F, II: 1
Veblen, O. F, I: 1
Vecchio, G. Del. FHM, III: 1
Verhoeff, F. H. F, II: 4
Viëtor, K. F, IV: 4
Viets, H. R. F, IV: 2
Vincent, J. H. FHM, II: 4
Viner, J. F, III: 3
Wagner, K. W. FHM, I: 4
Walsh, J. L. F, I: 1
Wambaugh, S. F, III: 2
Warner, E. P. F, I: 4
Warren, B. E. F, I: 2
Warren, B. W. F, III: 1
Warren, C. H. F, II: 1
Washburn, H. B. F, IV: 1
Watson, J. B. F, IV: 1
Wearn, J. T. F, II: 4
Weatherby, C. A. F, II: 2
Webster, D. L. F, I: 2
Webster, E. S. F, III: 4
Weiser, H. B. F, I: 3
Wells, F. L. F, IV: 1
Westergaard, H. M. F, I: 4
Weston, G. B. F, IV: 3
Weston, K. E. F, IV: 4
Weston, W. H., Jr. F, II: 2
Wetmore, R. H. F, II: 2
Weyl, H. FHM, I: 1
Weysse, A. W. F, II: 3
Whipple, F. L. F, I: 1
White, P. D. F, II: 4
Whitehead, A. N. F, I: 1
Whitehead, T. N. F, III: 3
Whitlock, H. P. F, II: 1
Whitman, E. A. F, III: 1
Whitmore, F. C. F, I: 3
Whitney, W. R. F, I: 3
Whittlesey, D. S. F, II: 1

Widder, D. V.	F, I: 1
Wieland, H.	FHM, I: 3
Wild, P. S., Jr.	F, III: 2
Wilkins, E. H.	F, IV: 3
Williams, J. H.	F, III: 3
Williams, R. S.	F, I: 3
Willis, B.	F, II: 1
Willits, J. H.	F, III: 3
Willoughby, W. F.	F, III: 2
Willoughby, W. W.	F, III: 2
Wilson, C. E.	F, III: 4
Wilson, E. B.	F, I: 2
Wilson, E. B., Jr.	F, I: 3
Wilson, G. G.	F, III: 2
Winlock, H. E.	F, IV: 4
Winship, L. L.	F, III: 4
Wislocki, G. B.	F, II: 3
Wissler, C.	F, IV: 2
Wolbach, S. B.	F, II: 4
Wolfson, H. A.	F, IV: 3
Wolman, L.	F, III: 3
Wood, R. W.	F, I: 2
Woodworth, R. S.	F, IV: 1
Worrell, W. H.	F, IV: 3
Wright, Lord.	FHM, III: 1
Wright, C. H. C.	F, IV: 4
Wright, F. E.	F, II: 1
Wright, Q.	F, III: 2
Wu, J. C. H.	FHM, III: 1
Wulff, J.	F, I: 4
Wyman, J., Jr.	F, II: 3
Wyzanski, C. E., Jr.	F, III: 1
Yeomans, H. A.	F, III: 2
Yerkes, R. M.	F, IV: 1
Young, B. L.	F, III: 4
Young, O. D.	F, III: 4
Young, R. C.	F, I: 3
Zeleny, J.	F, I: 2
Zimmerman, C. C.	F, III: 3
Zworykin, V. K.	F, I: 4

STATUTES AND STANDING VOTES.

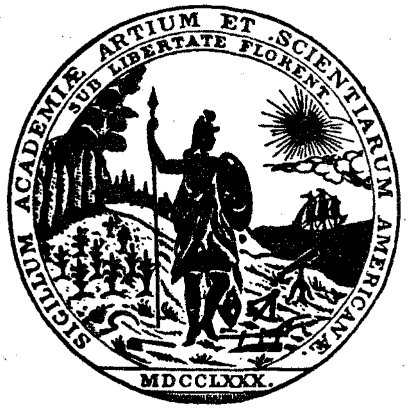
STATUTES.

Adopted November 8, 1911: *amended May* 8, 1912, *January* 8, *and May* 14, 1913, *April* 14, 1915, *April* 12, 1916, *April* 10, 1918, *May* 14, 1919, *February* 8, *April* 12, *and December* 13, 1922, *February* 14, *March* 14, *and October* 10, 1923, *March* 10, 1926, *May* 9, 1928, *April* 8 *and November* 11, 1931, *April* 12, 1933, *February* 14, 1934, *December* 14, 1938, *January* 11, *April* 12, 1939, *May* 8, 1940, *May* 14, 1941, *November* 18, 1942, *and January* 12, 1944.

CHAPTER I.

The Corporate Seal.

Article 1. The Corporate Seal of the Academy shall be as here depicted:


SIGILLUM ACADEMIÆ ARTIUM ET SCIENTIARUM AMERICANÆ
SUB LIBERTATE FLORENT
MDCCLXXX.

Article 2. The Recording Secretary shall have the custody of the Corporate Seal.

See Chap. v, art. 3; chap. vi, art. 2.

CHAPTER II.

Fellows and Foreign Honorary Members and Dues.

Article 1. The Academy shall consist of Fellows, elected from the citizens or residents of the United States of America, Fellows Emeriti, and Foreign Honorary Members. They are arranged in four Classes, according to the Arts and Sciences in which they are severally proficient, and each Class shall be divided into four Sections, namely:

Class I. *The Mathematical and Physical Sciences*

Section 1. Mathematics and Astronomy
Section 2. Physics
Section 3. Chemistry
Section 4. Technology and Engineering

Class II. *The Natural and Physiological Sciences*

Section 1. Geology, Mineralogy, and Physics of the Globe
Section 2. Botany
Section 3. Zoölogy and Physiology
Section 4. Medicine and Surgery

Class III. *The Social Arts*

Section 1. Jurisprudence
Section 2. Government, International Law, and Diplomacy
Section 3. Economics and Sociology
Section 4. Administration and Affairs

Class IV. *The Humanities*

Section 1. Theology, Philosophy, and Psychology
Section 2. History, Archæology, and Anthropology
Section 3. Philology
Section 4. The Fine Arts and Belles Lettres

Article 2. The number of Fellows shall not exceed Eight hundred, of whom not more than Six hundred shall be residents of Massachusetts, nor shall there be more than Two hundred and twenty in any one Class.

Fellows of the Academy on retiring from their academic or other regular duties may, if they so desire and with the approval of the Council, be transferred to the status of Fellows Emeriti. Fellows Emeriti shall be exempt from the payment of dues and may not hold office in the Academy, but shall have all the other privileges of Fellowship. In the published lists of the membership of the Academy, Fellows Emeriti shall be separately classified, and shall be outside the statutory limit set on the number of Fellows.

ARTICLE 3. The number of Foreign Honorary Members shall not exceed One hundred and thirty. They shall be chosen from among citizens of foreign countries most eminent for their discoveries and attainments in any of the Classes above enumerated. There shall not be more than Thirty-five in any one Class.

ARTICLE 4. If any person, after being notified of his election as Fellow, shall neglect for six months to accept in writing, or, if a Fellow resident within fifty miles of Boston shall neglect to pay his Admission Fee, his election shall be void; and if any Fellow resident within fifty miles of Boston shall neglect to pay his Annual Dues for six months after they are due, provided his attention shall have been called to this Article of the Statutes in the meantime, he shall cease to be a Fellow; but the Council may suspend the provisions of this Article for a reasonable time.

With the previous consent of the Council, the Treasurer may dispense (*sub silentio*) with the payment of the Admission Fee or of the Annual Dues or both whenever he shall deem it advisable. In the case of officers of the Army or Navy who are out of the Commonwealth on duty, payment of the Annual Dues may be waived during such absence if continued during the whole financial year and if notification of such expected absence be sent to the Treasurer. Upon similar notification to the Treasurer, similar exemption may be accorded to Fellows subject to Annual Dues, who may temporarily remove their residence for at least two years to a place more than fifty miles from Boston.

If any person elected a Foreign Honorary Member shall neglect for six months after being notified of his election to accept in writing, his election shall be void.

See Chap. vii, art. 2.

ARTICLE 5. Every Fellow resident within fifty miles of Boston hereafter elected shall pay an Admission Fee of Ten dollars, unless previously as an Associate he has paid an Admission Fee of like amount.

Every Fellow resident within fifty miles of Boston shall, and others may, pay such Annual Dues, not exceeding Fifteen dollars, as shall be voted by the Academy at each Annual Meeting, when they shall become due; but any Fellow shall be exempt from the annual payment if, at any time after his admission, he shall pay into the treasury Two hundred dollars in addition to his previous payments. Any Fellow shall also be exempt from Annual Dues who has paid such dues for forty years, or, having attained the age of seventy-five has paid dues for twenty-five years.

Fellows residing more than fifty miles from Boston elected after 1938 shall, and other non-resident Fellows may, pay annual dues of five dollars, which shall entitle them to all privileges of resident Fellows.

All Commutations of the Annual Dues shall be and remain permanently funded, the interest only to be used for current expenses.

Any Fellow not previously subject to Annual Dues who takes up his residence within fifty miles of Boston, shall pay to the treasurer within three months thereafter Annual Dues for the current year, failing which his Fellowship shall cease; but the Council may suspend the provisions of this Article for a reasonable time.

Only Fellows who pay Annual Dues or have commuted them may hold office in the Academy or serve on the Standing Committees or vote at meetings.

ARTICLE 6. Fellows who pay or have commuted the Annual Dues and Foreign Honorary Members shall be entitled to receive gratis one copy of all numbers of the Proceedings and Memoirs of the Academy which have been issued after their election.

See Chap. xi, art. 2.

ARTICLE 7. Diplomas signed by the President and the Vice-President of the Class to which the member belongs, and countersigned by the

Secretaries, shall be given to Foreign Honorary Members and to Fellows.

ARTICLE 8. If, in the opinion of a majority of the entire Council, any Fellow or Foreign Honorary Member shall have rendered himself unworthy of a place in the Academy, the Council shall recommend to the Academy the termination of his membership; and if three-fourths of the Fellows present, out of a total attendance of not less than fifty at a Stated Meeting, or at a Special Meeting called for the purpose, shall adopt this recommendation, his name shall be stricken from the Roll.

See Chap. iii; chap. vi, art. 1; chap. x, art. 1; chap. xi, art. 2.

CHAPTER III.

ELECTION OF FELLOWS AND FOREIGN HONORARY MEMBERS.

The procedure in the election of Fellows and Foreign Honorary Members shall be as follows:

Nominations to Fellowship or Foreign Honorary Membership in any section must be signed by two Fellows of that Section, or by three Fellows of any Section, and sent to the Corresponding Secretary accompanied by a statement of the qualifications of the nominee and brief biographical data.

Notice shall be sent to every Fellow not later than the fifteenth of January in each year, reminding him that all nominations must be in the hands of the Corresponding Secretary before the first of February following.

The Corresponding Secretary shall, on the second of February, transmit to the several Vice-Presidents the nominations for Fellows and Foreign Honorary Members in their respective classes. Each Class Committee shall, before the sixteenth of February, consider the nominations, and may add others for the purpose of securing proper membership in the Academy, to the end that those in the country of highest distinction in their several classes may be Fellows.

A list of the nominees, giving a brief account of each, with the names of the nominators, shall be sent to every Fellow with a request that he return the list with such confidential comments and indications of preference as he may choose to make.

All the nominations, with any comments thereon and with expressions of preference on the part of the Fellows, shall be referred to the appropriate Class Committees, which shall canvass them, and report their recommendations in writing to the Council before the Stated Meeting of the Academy in April.

Elections of Fellows and Foreign Honorary Members shall be made by the Council before the Annual Meeting in May, and announced at that meeting.

Persons nominated in any year, but not elected, may be carried over to the list of nominees for the next year at the discretion of the Council, but shall not be further continued unless renominated.

See Chap. ii; chap. vi, art. 1; chap. x, art. 1.

CHAPTER IV.

OFFICERS.

ARTICLE 1. The Officers of the Academy shall be a President (who shall be Chairman of the Council), four Vice-Presidents (one from each Class), a Corresponding Secretary (who shall be Secretary of the Council), a Recording Secretary, a Treasurer, a Librarian, and an Editor, all of whom shall be elected by ballot at the Annual Meeting, and shall hold their respective offices for one year, and until others are duly chosen and installed.

There shall be also sixteen Councillors, one from each Section of each Class. At each Annual Meeting four Councillors, one from each Class, shall be elected by ballot to serve for the full term of four years and until others are duly chosen and installed. The same Fellows shall not be eligible for two successive terms.

The Councillors, with the officers previously named, and the Chairmen of the House Committee and the Committee on Resources and Policy, *ex officiis*, shall constitute the Council.

See Chap. xi, art. 1.

ARTICLE 2. If any officer be unable, through death, absence, or disability, to fulfill the duties of his office, or if he shall resign, his place may be filled by the Council in its discretion for any part or the whole of the unexpired term.

Article 3. At the Stated Meeting in March, the President shall appoint a Nominating Committee of four Fellows having the right to vote, one from each Class. This Committee shall prepare a list of nominees for the several offices to be filled, and for the Standing Committees, and file it with the Recording Secretary not later than four weeks before the Annual Meeting.

See Chap. vi, art. 2.

Article 4. Independent nominations for any office, if signed by at least twenty Fellows having the right to vote, and received by the Recording Secretary not less than ten days before the Annual Meeting, shall be inserted in the call therefor, and shall be mailed to all the Fellows having the right to vote.

See Chap. vi, art. 2.

Article 5. The Recording Secretary shall prepare for use in voting at the Annual Meeting a ballot containing the names of all persons duly nominated for office.

CHAPTER V.

The President.

Article 1. The President, or in his absence the senior Vice-President present (seniority to be determined by length of continuous Fellowship in the Academy), shall preside at all meetings of the Academy. In the absence of all these officers, a Chairman of the meeting shall be chosen by ballot.

Article 2. Unless otherwise ordered, all Committees which are not elected by ballot shall be appointed by the presiding officer.

Article 3. Any deed or writing to which the Corporate Seal is to be affixed, except leases of real estate, shall be executed in the name of the Academy by the President or, in the event of his death, absence, or inability, by one of the Vice-Presidents, when thereto duly authorized.

See Chap. ii, art. 7; chap. iv, art. 1, 3; chap. vi, art. 2; chap. vii, art. 1; chap. x, art. 6; chap. xi, art. 1, 2; chap. xii, art. 1.

CHAPTER VI.

The Secretaries.

Article 1. The Corresponding Secretary shall conduct the correspondence of the Academy and of the Council, recording or making an entry of all letters written in its name, and preserving for the files all official papers which may be received. At each meeting of the Council he shall present the communications addressed to the Academy which have been received since the previous meeting, and at the next meeting of the Academy he shall present such as the Council may determine.

He shall notify all persons who may be elected Fellows or Foreign Honorary Members, send to each a copy of the Statutes, and on their acceptance issue the proper Diploma. He shall also notify all meetings of the Council; and in case of the death, absence, or inability of the Recording Secretary he shall notify all meeting of the Academy.

Under the direction of the Council, he shall keep a List of the Fellows and Foreign Honorary Members, arranged in their several Classes and Sections. It shall be printed annually and issued as of the first day of July.

See Chap. ii, art. 7; chap. iii; chap. iv, art. 1; chap. x, art. 6; chap. xi, art. 1; chap. xii, art. 1.

Article 2. The Recording Secretary shall have the custody of the Charter, Corporate Seal, Archives, Statute-Book, Journals, and all litersry papers belonging to the Academy.

Fellows borrowing such papers or documents shall receipt for them to their custodian.

The Recording Secretary shall attend the meetings of the Academy and keep a faithful record of the proceedings with the names of the Fellows present; and after each meeting is duly opened, he shall read the record of the preceding meeting.

He shall notify the meetings of the Academy to each Fellow and by mail at least seven days beforehand, and in his discretion may also cause the meetings to be advertised; he shall apprise Officers and Committees of their election or appointment, and inform the Treasurer of appropriations of money voted by the Academy.

After all elections, he shall insert in the Records the names of the Fellows by whom the successful nominees were proposed.

He shall send the Report of the Nominating Committee in print to every Fellow having the right to vote at least three weeks before the Annual Meeting.

See Chap. iv, art. 3.

In the absence of the President and of the Vice-President he shall, if present, call the meeting to order, and preside until a Chairman is chosen.

See Chap. i; chap. ii, art. 7; chap. iv, art. 3, 4, 5; chap. x, art. 6; chap. xi, art. 1, 2; chap. xii, art. 1, 3.

ARTICLE 3. The Secretaries, with the Editor, shall have authority to publish such of the records of the meetings of the Academy as may seem to them likely to promote its interests.

CHAPTER VII.

THE TREASURER AND THE TREASURY.

ARTICLE 1. The Treasurer shall collect all money due or payable to the Aacedmy and all gifts or bequests made to it. He shall pay all bills due and payable by the Academy when approved by the proper officers. He shall sign all leases of real estate in the name of the Academy. He shall be the official custodian of all bonds, stocks and other securities and, with the written approval of any one member of the Committee on Finance, he shall have full authority to sell and transfer, invest and reinvest from time to time in such manner and upon such terms as shall to him seem best, the whole or any part of the personal property of the said Academy.

He shall keep a faithful account of all receipts and expenditures, submit his accounts annually to the Auditing Committee, and render them at the expiration of his term of office, or whenever required to do so by the Academy or the Council.

He shall keep separate accounts of the income of the Rumford Fund, and of all other special Funds, and of the Appropriation thereof, and render them annually.

His accounts shall always be open to the inspection of the Council.

ARTICLE 2. He shall report annually to the Council at its March meeting on the expected income of the various Funds and from all other sources during the ensuing financial year. He shall also report the names of all Fellows who may be then delinquent in the payment of their Annual Dues.

ARTICLE 3. He shall give such security for the trust reposed in him as the Academy may require.

ARTICLE 4. With the approval of a majority of the Committee on Finance, he may appoint an Assistant Treasurer to perform his duties, for whose acts, as such assistant, he shall be responsible; or, with like approval and responsibility, he may employ any Trust Company doing business in Boston as his agent for the same purpose, the compensation of such Assistant Treasurer or agent to be fixed by the Committee on Finance and paid from the Funds of the Academy.

ARTICLE 5. At the Annual Meeting he shall report in print all his official doings for the preceding year, stating the amount and condition of all the property of the Academy entrusted to him, and the character of the investments.

ARTICLE 6. The Financial Year of the Academy shall begin with the first day of April.

ARTICLE 7. No person or committee shall incur any debt or liability in the name of the Academy, unless in accordance with a previous vote and appropriation therefor by the Academy or the Council, or sell or otherwise dispose of any property of the Academy, except cash or invested funds, without previous consent and approval of the Council.

See Chap. ii, art. 4, 5; chap. vi, art. 2; chap. x, art. 6; chap. xi, art. 1, 2, 3; chap. xii, art. 1.

CHAPTER VIII.

THE LIBRARIAN AND THE LIBRARY.

ARTICLE 1. The Librarian shall have charge of the printed books, keep a correct catalogue thereof, and provide for their delivery from the Library.

At the Annual Meeting, as Chairman of the Committee on the Library, he shall make a Report on its condition.

Article 2. In conjunction with the Committee on the Library he shall have authority to expend such sums as may be appropriated by the Academy for the purchase of books, periodicals, etc., and for defraying other necessary expenses connected with the Library.

Article 3. All books procured from the income of the Rumford Fund or of other special Funds shall contain a book-plate expressing the fact.

Article 4. Books taken from the Library shall be receipted for to the Librarian or his assistant.

Article 5. Books shall be returned in good order, regard being had to necessary wear with good usage. If any book shall be lost or injured, the Fellow to whom it stands charged shall replace it by a new volume or by a new set, if it belongs to a set, or pay the current price thereof to the Librarian, whereupon the the remainder of the set, if any, shall be delivered to the Fellow so paying, unless such remainder be valuable by reason of association.

Article 6. All books shall be returned to the Library for examination at least one week before the Annual Meeting.

Article 7. The Librarian shall have the custody of the Publications of the Academy. With the advice and consent of the President, he may effect exchanges with other associations.

See Chap. ii, art. 6; chap. xi, art. 1, 2.

CHAPTER IX.

The Editor and the Publications.

Article 1. The Editor shall have charge of the conduct through the press of the Proceedings and the Memoirs, and all correspondence relative thereto, and shall have power to fix the price at which individual numbers of the Proceedings and Memoirs are sold.

The Editor shall select as Assocaite Editor one member of the Committee of Publication, and the Associate Editor shall assist the Editor in the duties of his office in such way as the two shall find most convenient.

Article 2. In conjunction with the Committee of Publication, the Editor shall have authority to expend such sums as may be appropriated by the Academy for printing the publications and for defraying other expenses therewith connected.

Article 3. All publications which are financed in whole or in part from the income of the Rumford Fund or from the income of other special funds, and all publications of work done with the aid of the Rumford Fund or other special funds, shall contain a conspicuous statement of this fact.

Article 4. Two hundred extra copies of each paper printed in the Proceedings or Memoirs shall be placed at the disposal of the author without charge.

If, on account of the number of communications offered for publication, it shall be necessary to decline for publication communications otherwise acceptable, members of the Academy shall be given preference in each of the several Classes over non-members; but whenever it shall be necessary to exercise this preference, the Editor shall inform the Council of the fact.

See Chap. iv, art. 1; chap. vi, art. 3; chap. x, art. 6; chap. xi, art. 2, sect. 5.

CHAPTER X.

The Council.

Article 1. The Council shall exercise a discreet supervision over all nominations and elections to membership, and in general supervise all the affairs of the Academy not explicitly reserved to the Academy as a whole or entrusted by it or by the Statutes to standing or special committees.

It shall consider all nominations duly sent to it by any Class Committee, and act upon them in accordance with the provisions of Chapter III.

With the consent of the Fellow interested, it shall have power to make transfers between the several Sections, reporting its action to the Academy.

See Chap. iii; chap. xi, art. 1.

ARTICLE 2. Nine members shall constitute a quorum.

ARTICLE 3. It shall establish rules and regulations for the transaction of its business, and provide all printed and engraved blanks and books of record.

ARTICLE 4. It shall act upon all resignations of officers, and all resignations and forfeitures of Fellowship; and cause the Statutes to be faithfully executed.

It shall appoint all agents and subordinates not otherwise provided for by the Statutes, prescribe their duties, and fix their compensation. They shall hold their respective positions during the pleasure of the Council.

ARTICLE 5. It may appoint, for terms not exceeding one year, and prescribe the functions of, such committees of its number, or of the Fellows of the Academy, as it may deem expedient, to facilitate the administration of the affairs of the Academy or to promote its interests.

ARTICLE 6. At its March meeting it shall receive reports from the President, the Secretaries, the Treasurer, and the Standing Committees, on the appropriations severally needed for the ensuing financial year. At the same meeting the Treasurer shall report on the expected income of the various Funds and from all other sources during the same year.

A report from the Council shall be submitted to the Academy, for action, at the March meeting, recommending the appropriation which in the opinion of the Council should be made.

On the recommendation of the Council, special appropriations may be made at any Stated Meeting of the Aacdemy, or at a Special Meeting called for the purpose.

See Chap. xi, art. 3.

ARTICLE 7. It shall report at every meeting of the Academy such business as it may deem advisable to present.

See Chap. ii, art. 4, 5, 8; chap. iv, art. 1, 2; chap. vi, art. 1; chap. vii, art. 1; chap. xii, art. 1, 4.

CHAPTER XI.

STANDING COMMITTEES.

ARTICLE 1. The Class Committee of each Class shall consist of the Vice-President, who shall be chairman, and the four Councillors of the Class, together with such other officer or officers annually elected as may belong to the Class. It shall consider nominations to Fellowship in its own Class, and report in writing to the Council such as may receive at a Class Committee Meeting a majority of the votes cast, provided at least three shall have been in the affirmative.

See Chap. iii.

ARTICLE 2. At the Annual Meeting the following Standing Committees shall be elected by ballot to serve for the ensuing year.

(i) *The Committee on Finance*, to consist of four Fellows, who shall have general oversight of the funds and investments of the Academy.

See Chap. iv, art. 3; chap. vii, art. 1, 4; chap. x, art. 6.

(ii) *The Committee on Policy and Resources* to consist of five Fellows and the President, *ex officio*, one of the five elected members to be elected each year to serve for a term of five years, except that the five elected in 1939 shall be elected for terms of one, two, three, four, and five years respectively, the Committee to concern itself with procuring funds for the Academy, to study the activities and needs of the Academy, and to recommend, for the approval of the Council, means by which the functions and purposes of the Academy may best be fulfilled.

(iii) *The Rumford Committee*, to consist of seven Fellows, who shall report to the Academy on all applications and claims for the Rumford Premium. It alone shall authorize the purchase of books, publications and apparatus at the charge of the income from the Rumford Fund, and generally shall see to the proper execution of the trust.

See Chap. iv, art. 3; chap. x, art. 6.

(iv) *The Cyrus Moors Warren Committee,* to consist of seven Fellows, who shall consider all applications for appropriations from the income of the Cyrus Moors Warren Fund, and generally shall see to the proper execution of the trust.

See Chap. iv, art. 3; chap. x, art. 6.

(v) *The Committee of Publication,* to consist of the Editor, *ex officio,* as Chairman, and four other Fellows, one from each Class, to whom all communications submitted to the Academy for publication shall be referred, and to whom the printing of the Proceedings and the Memoirs shall be entrusted.

It shall fix the price at which volumes of the publications shall be sold, but Fellows may be supplied at half price with volumes and with single publications which they are not entitled to receive gratis.

It shall determine when the pressure of material offered for publication makes it necessary to give preference to members of the Academy as compared with non-members, or to give priority to certain members as compared with others, and to what extent this preference or priority shall be applied in each of the four Classes, to the end that a proper balance of the facilities of publication with respect to subject matter and authors may be maintained.

See Chap. iv, art. 3; chap. vi, art. 1, 3; chap. ix; chap. x, art. 6.

(vi) *The Committee on the Library,* to consist of the Librarian, *ex officio,* as Chairman, and four other Fellows, one from each Class, who shall examine the Library and make an annual report on its condition and management.

See Chap. iv, art. 3; chap. viii, art. 1, 2; chap. x, art. 6.

(vii) *The House Committee,* to consist of four Fellows, who shall have charge of all expenses connected with the House, including the general expenses of the Academy not specifically assigned to the care of other Committees or Officers.

See Chap. iv, art. 1, 3; chap. x, art. 6.

(viii) *The Committee on Meetings,* to consist of the President, the Recording Secretary, and four other Fellows, who shall have charge of plans for meetings of the Academy.

See Chap. iv, art. 3; chap. x, art. 6.

(ix) *The Auditing Committee,* to consist of two Fellows, who shall audit the accounts of the Treasurer, with power to employ an expert and to approve his bill.

See Chap. iv, art. 3; chap. vii, art. 1; chap. x, art. 6.

(x) *The Committee on Biographical Notices,* to consist of six Fellows, two to be elected each year, one of them to be a Secretary of the Academy, to see that biographical records of the Fellows and Foreign Honorary Members are provided.

ARTICLE 3. The Standing Committees shall report annually to the Council in March on the appropriations severally needed for the ensuing financial year; and all bills incurred on account of these Committees, within the limits of the several appropriations made by the Academy, shall be approved by their respective Chairmen.

In the absence of the Chairman of any Committee, bills may be approved by any member of the Committee whom he shall designate for the purpose.

See Chap. vii, art. 1, 7; chap. x, art. 6.

CHAPTER XII.

MEETINGS, COMMUNICATIONS, AND AMENDMENTS.

ARTICLE 1. There shall be annually eight Stated Meetings of the Academy, namely, on the second Wednesday of October, November, December, January, February, March, April, and May. Only at these meetings, or at adjournments thereof regularly notified, or at Special Meetings called for the purpose, shall appropriations of money be made or amendments of the Statutes or Standing Votes be effected.

The Stated Meeting in May shall be the Annual Meeting of the Corporation.

Special Meetings shall be called by either of the Secretaries at the request of the President, of a Vice-President, of the Council, or of ten Fellows having the right to vote; and notifications thereof shall state the purpose for which the meeting is called.

The Council shall have authority, as occasion may demand, to arrange additional meetings and to cancel any of the Statutory meetings, except that meetings for transacting business shall be held as required by the Statutes.

ARTICLE 2. Twenty-five Fellows having the right to vote shall constitute a quorum for the transaction of business at Stated or Special Meetings. Eighteen Fellows shall be sufficient to constitute a meeting for literary or scientific communications and discussions.

ARTICLE 3. Upon the request of the presiding officer or the Recording Secretary, any motion or resolution offered at any meeting shall be submitted in writing.

ARTICLE 4. No report of any paper presented at a meeting of the Academy shall be published by any Fellow without the consent of the author; and no report shall in any case be published by any Fellow in a newspaper as an account of the proceedings of the Academy without the previous consent and approval of the Council. The Council, in its discretion, by a duly recorded vote, may delegate its authority in this regard to one or more of its members.

ARTICLE 5. Fellows may introduce guests at any of the literary or scientific meetings of the Academy.

ARTICLE 6. The Academy shall not express its judgment on literary or scientific memoirs or performances submitted to it, or included in its Publications.

ARTICLE 7. All proposed Amendments of the Statutes shall be referred to a committee, and on its report, at a subsequent Stated Meeting or at a Special Meeting called for the purpose, two-thirds of the ballots cast, and not less than twenty-five, must be affirmative to effect enactment.

ARTICLE 8. Standing Votes may be passed, amended, or rescinded at a Stated Meeting, or at a Special Meeting called for the purpose, by a vote of two-thirds of the members present. They may be suspended by a unanimous vote.

See Chap. ii, art. 5, 8; chap. iii; chap. iv, art. 3, 4, 5; chap. v, art. 1; chap. vi, art. 1, 2; chap. x. art. 7.

STANDING VOTES

1. Communications of which notice has been given to either of the Secretaries shall take precedence of those not so notified.

2. Fellows may take from the Library six volumes at any one time, and may retain them for three months, and no longer. Upon special application, and for adequate reasons assigned, the Librarian may permit a larger number of volumes, not exceeding twelve, to be drawn from the Library for a limited period.

3. Works published in numbers, when unbound, shall not be taken from the Hall of the Academy without the leave of the Librarian.

4. Communications offered for publication in the Proceedings or Memoirs of the Academy shall not be accepted for publication before the author either himself or through some agent, shall have informed the Committee on Meetings of his readiness to use such time as the Committee may assign him at such meeting as may be convenient both to him and to the Committee, for the purpose of presenting to the Academy a general statement of the nature and significance of the results contained in his communication.

RUMFORD PREMIUM

In conformity with the terms of the gift of Sir Benjamin Thompson, Count Rumford, of a certain Fund to the American Academy of Arts and Sciences, and with a decree of the Supreme Judicial Court of Massachusetts for carrying into effect the general charitable intent and purpose of Count Rumford, as expressed in his letter of gift, the Academy is empowered to make from the income of the Rumford Fund, as it now exists, at any Annual Meeting, an award of a gold and a silver medal, being together of the intrinsic value of three hundred dollars, as a Premium to the author of any important discovery or useful improvement in light or heat, which shall have been made and published by printing, or in any way made known to the public, in any part of the continent of America, or any of the American islands; preference always being given to such discoveries as, in the opinion of the Academy, shall tend most to promote the good of mankind; and, if the Academy sees fit, to add to such medals, as a further Premium for such discovery and improvement, a sum of money not exceeding three hundred dollars.

PERMANENT SCIENCE FUND

By an Agreement and Declaration of Trust dated Sept. 5, 1928, the Boston Safe Deposit and Trust Company agrees to accept and hold gifts made to it as Trustee of the Permanent Science Fund . . . and to pay the income . . . to the American Academy of Arts and Sciences, to be applied to such scientific research "as shall be deemed charitable within the broadest possible construction of that term" . . . in such sciences as Mathematics, Physics, Chemistry, Astronomy, Geology, Geography, Zoology, Botany, Anthropology, Psychology, Sociology and Economy, History and Philology, Engineering, Medicine and Surgery, Agriculture, Manufacture and Commerce, Education and any other science of any nature or description whether or not now known or now recognized as scientific; and may be applied to or through public or private associations, societies or institutions, . . . or to or through one or more individuals.

Disbursements from income are voted by the Council of the Academy upon recommendations from the Committee on the Permanent Science Fund. A brochure comprising the First Decennial Report on the history and activities of this committee and a copy of the Agreement and Declaration of Trust is available on request to the Trustee at 100 Franklin Street, Boston, Mass.

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